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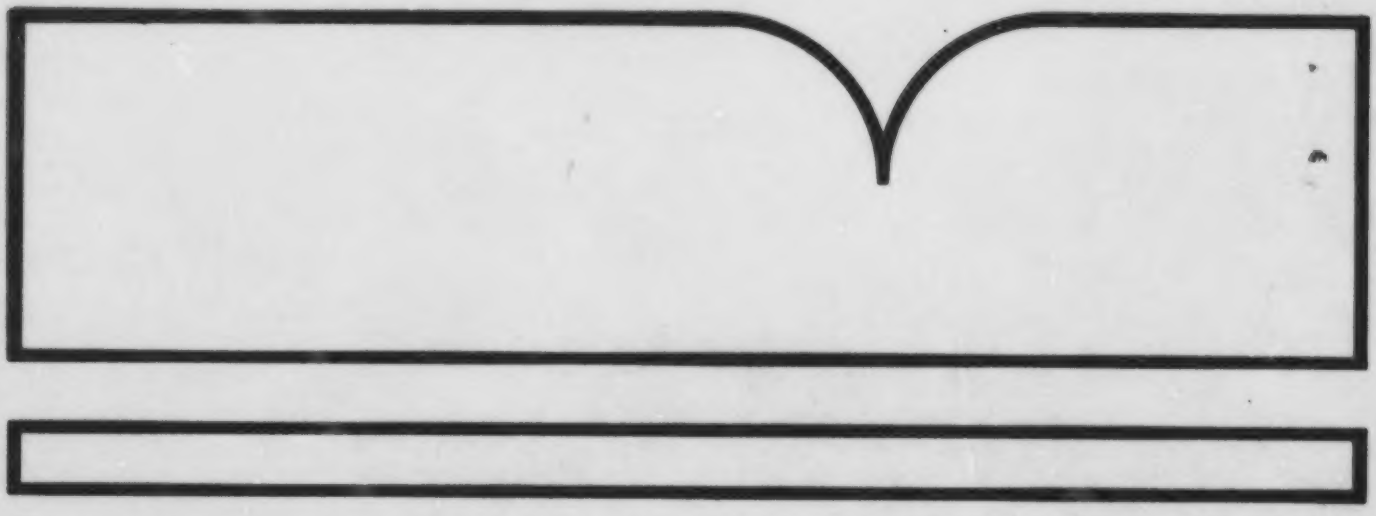
Ohio River Basin Energy Study
Urbana, IL

Prepared for

Environmental Protection Agency
Washington, DC

Oct 81



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ECONOMIC LOSSES IN THE COLUMBUS SMSA DUE TO LONG-RANGE TRANSPORT OF AIRBORNE RESIDUALS IN THE OHIO RIVER BASIN ENERGY STUDY REGION

By

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Prepared for

Ohio River Basin Energy Study (ORBES)

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16. ABSTRACT

This report was prepared as part of the Ohio River Basin Energy Study (ORBES), a multidisciplinary policy research program supported by the Environmental Protection Agency. The ORBES region covers all of Kentucky, most of West Virginia, southwestern Pennsylvania, and substantial portions of Illinois, Indiana and Ohio. Central Ohio is an area where the long-range transport of air pollutants is a problem, and a relatively small increase in pollution emitted from sources within the SMSA could cause the area to violate federal primary standards for sulfur dioxide and particulates.

This report estimates the potential loss in economic product to the Columbus SMSA by calculating the difference in economic output between (1) the projected increase in potential output possible under existing air quality regulations without additional background pollution from new out-of-area fossil fuel power plants and (2) the projected increase in output possible when this additional source of pollution is taken into account. Estimated losses are provided for seven different ORBES scenarios.

17. KEY WORDS AND DOCUMENT ANALYSIS

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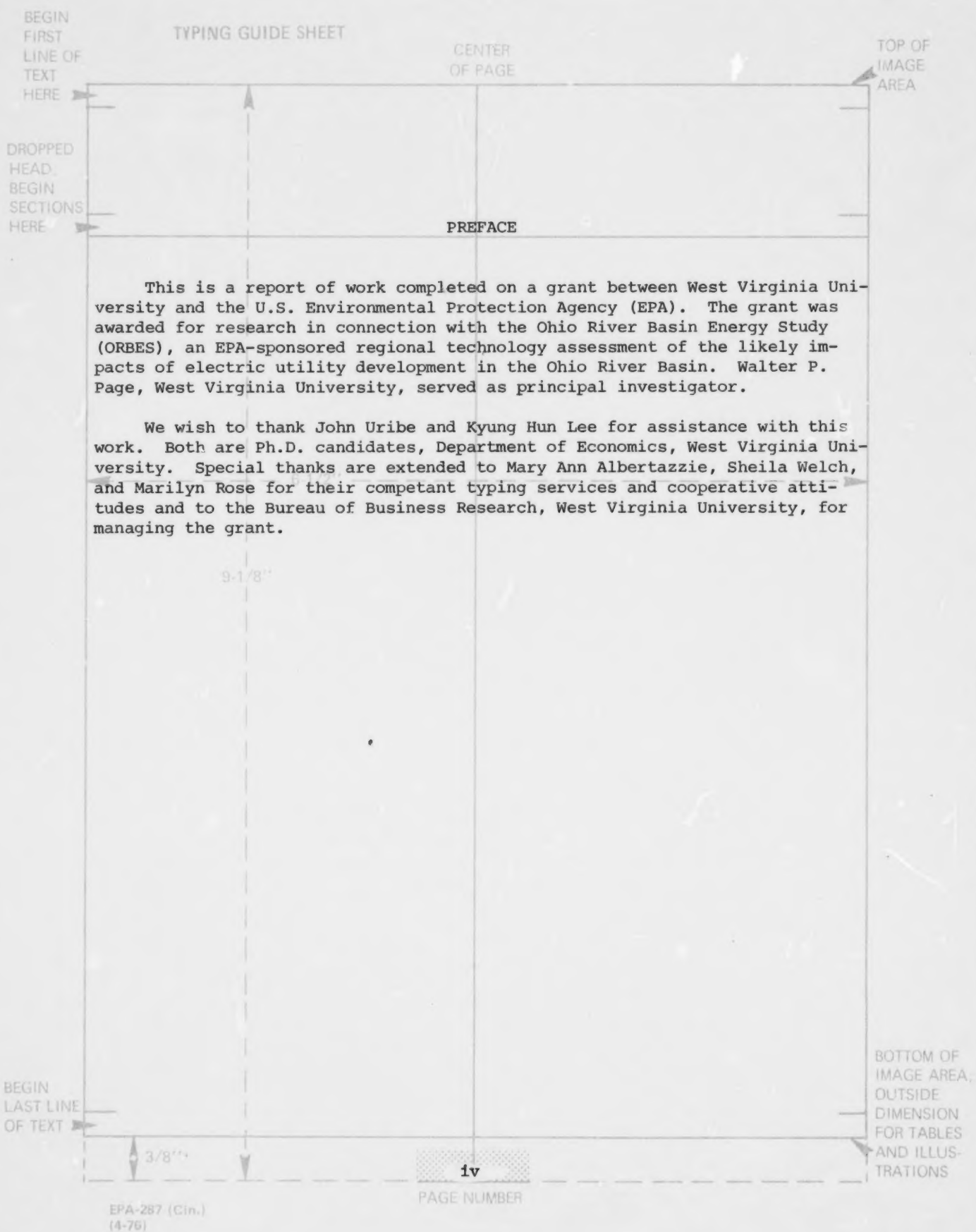
FOREWORD

The Ohio River Basin Energy Study (ORBES) is an interdisciplinary, multi-university inquiry into the environmental, economic, and social impacts of energy facility development in a major portion of the Ohio River Basin. The study was initiated by the U.S. Environmental Protection Agency in 1976 in response to a directive from the U.S. Senate Appropriations Committee.

Most of the ORBES research was conducted by a group of faculty members at the University of Illinois, Indiana University, the University of Kentucky, the University of Louisville, The Ohio State University, the University of Pittsburgh, Purdue University, and West Virginia University. In a few instances, the necessary expertise was found at other universities or independent research organizations.

This report is one of a series produced in support of the overall ORBES assessment. For a summary of the entire study, see Ohio River Basin Energy Study (ORBES): Main Report, by the ORBES Core Team, also being published by the U.S. Environmental Protection Agency.



This is a report of work completed on a grant between West Virginia University and the U.S. Environmental Protection Agency (EPA). The grant was awarded for research in connection with the Ohio River Basin Energy Study (ORBES), an EPA-sponsored regional technology assessment of the likely impacts of electric utility development in the Ohio River Basin. Walter P. Page, West Virginia University, served as principal investigator.

We wish to thank John Uribe and Kyung Hun Lee for assistance with this work. Both are Ph.D. candidates, Department of Economics, West Virginia University. Special thanks are extended to Mary Ann Albertazzie, Sheila Welch, and Marilyn Rose for their competant typing services and cooperative attitudes and to the Bureau of Business Research, West Virginia University, for managing the grant.

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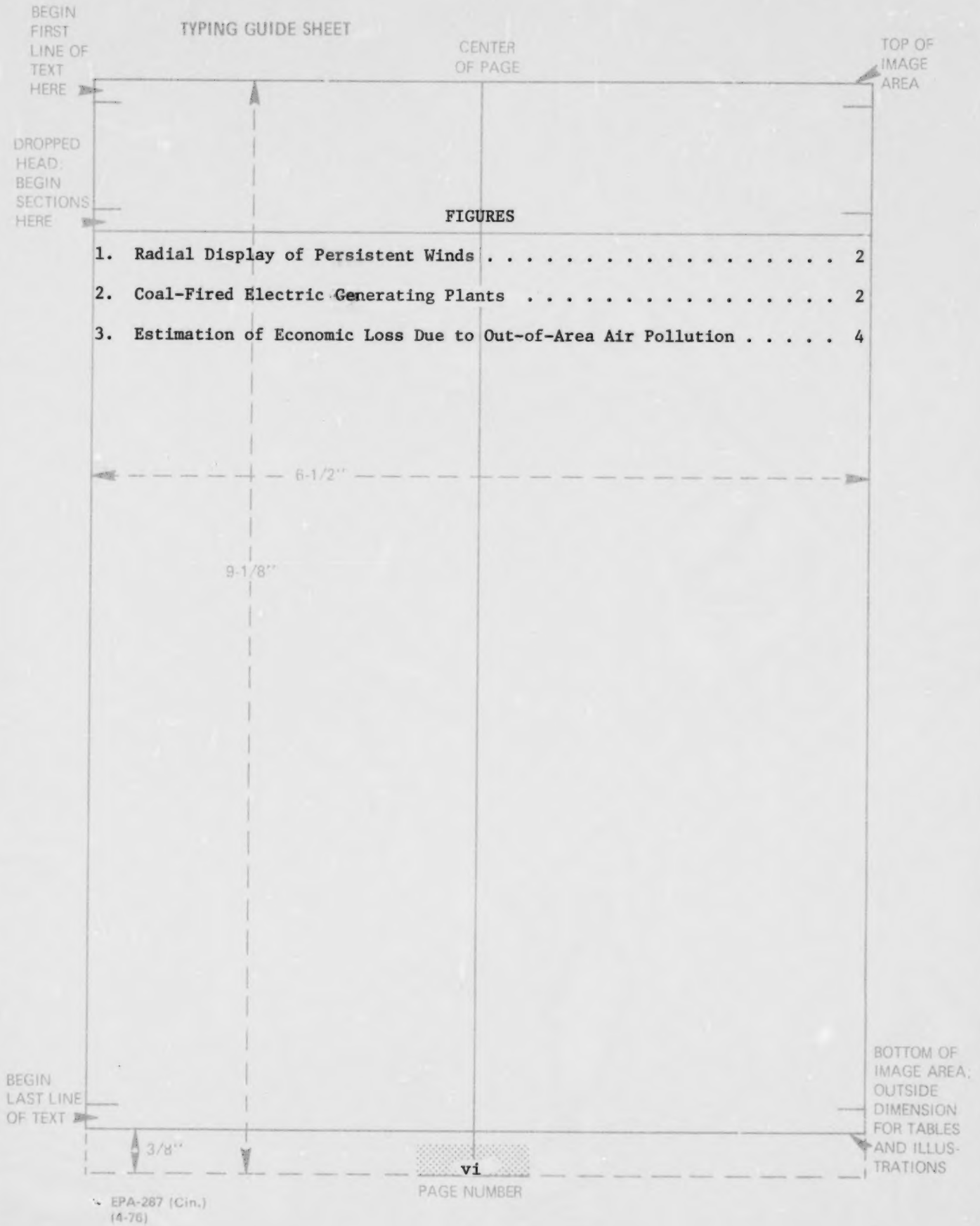
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SECTION 1

INTRODUCTION

One of the important findings from ORBES air quality work has been to verify the existence of long-range transport of point source air pollution. In general, whenever a large number of high emission sources of a pollutant, such as sulfur dioxide (SO_2), are located in the direct path of a persistent wind pattern, the result is a source intensification of that pollutant. Work done by Teknekron Research, Inc., under contract with the Environmental Protection Agency (EPA), has demonstrated that concentrations of SO_2 originating from point sources may be carried by persistent winds as far as 150-300 kilometers and transformed into sulfates.[1] This pollution contributes to what is known as background pollution in areas a considerable distance away from the primary source. Background pollution is that portion of a given area's ambient air pollution which is not directly attributable to point sources within the area itself.

Central Ohio is a region where the long-range transport problem is of concern. This area has been shown to be a recipient of sulfate pollution generated by sources in southern Ohio and Kentucky.[2] There is evidence that this phenomenon has contributed significantly to the periodic inability of Columbus, Ohio, to meet National Ambient Air Quality Standards (NAAQS) for particulates (of which sulfates contribute a significant percentage).

Figure 1 shows a radial display of persistent winds in the Columbus area. The distance from the inner circle to the outer circle represents ten cases of extreme persistence per year. This radial display pattern is similar to those found in pollutant emitting areas to the south and west of the Columbus Standard Metropolitan Statistical Area (SMSA).[3] The large arrows show the generally northeasterly wind pattern typical of the Ohio River Basin.

Associated with this persistent wind pattern in the Ohio River Basin is a large concentration of SO_2 and particulate sources, particularly coal-fired power plants. The approximate locations of these electric power plants are shown in Figure 2.[4] There are some 26 coal-fired power plants to the southwest of the Columbus SMSA within the area of the map shown in Figure 2.

This concentration of power plants, combined with the persistent wind pattern described above, suggests that sources of air pollution outside of the Columbus area may be contributing to the SMSA background concentrations of particulate, sulfur dioxide, and sulfate pollution. Given this background pollution, a relatively small increase in pollution emitted from sources within the SMSA could cause the area to violate federal primary standards for SO_2 and particulates.

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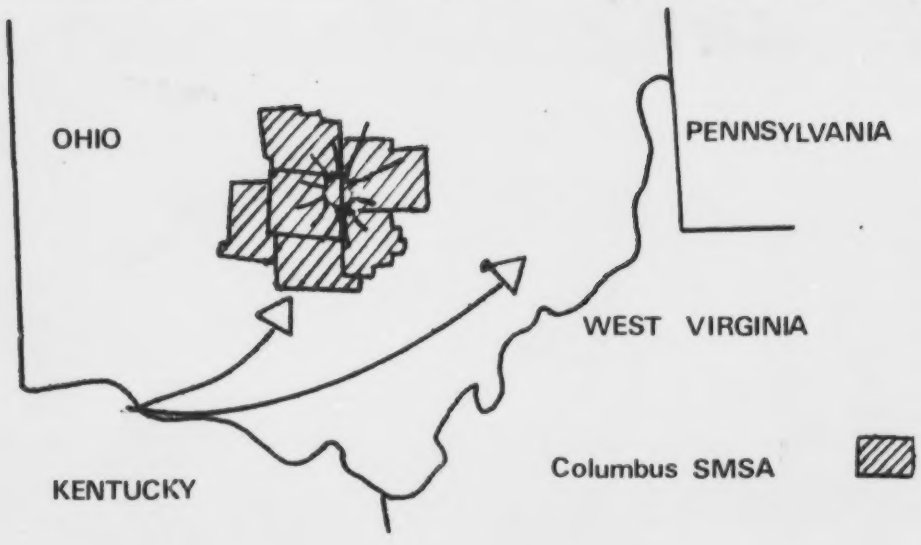

Figure 1. Radial Display of Persistent Winds

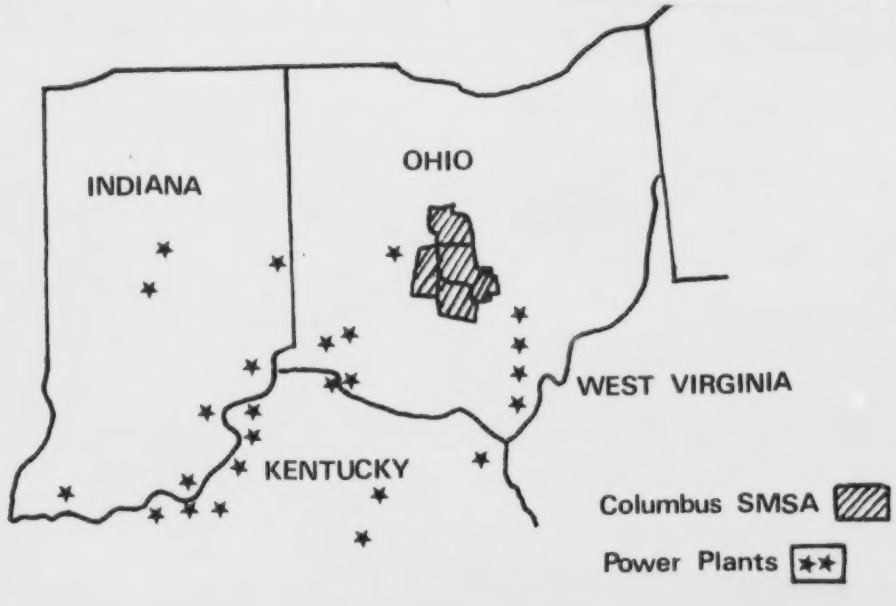

Figure 2. Coal-Fired Electric Generating Plants

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In the context of the long-range transport problem, the economic implications of federal air quality standards are far-reaching. In effect, the Columbus SMSA may be denied economic growth at some point in the future because of air pollution originating outside of the area. If a significant portion of the SMSA's allowable pollutant emissions are already taken by outside sources, new industrial facilities may be denied permits by air quality authorities. The resulting economic losses from foregone industrial activity could be quite large in an area such as the Columbus SMSA. The problem of interregional air pollution transport is briefly mentioned in Section 110 of the Clean Air Act,[5] as amended, which requires that State Implementation Plan (SIP) revisions not prevent or interfere with attainment or maintenance of air quality in other states.

Air quality in the Columbus SMSA is deteriorating and at some point in the future major new stationary sources of air pollution may be denied permits by the state under the provisions of the Clean Air Act. Of major concern to Ohio air quality officials is the fact that between 67 and 103 new fossil fuel power plants could be sited in Ohio, Kentucky, Indiana, and Illinois within the next 20 years.[6] If Teknekron's assessment of long-range air pollution transport potential is correct, these additional power plants could bring a halt to new industrial growth in the Columbus area. The question, then, is will air pollution from new fossil fuel power plants in Ohio, Kentucky, Indiana, and Illinois impose constraints upon future economic activity in the Columbus SMSA under the NAAQS of the Clean Air Act? The curve ec in Figure 3 represents air pollution associated with economic output in the Columbus SMSA. Suppose the maximum permitted pollution level is Op. Assume emissions due to local economic growth will cause this level to be reached in the year 1990. After this date, new industrial permits will be denied by air quality authorities under the provisions of the primary standards of the Clean Air Act. The effect of new out-of-area background pollution from fossil fuel power plants is to use up part of the permitted increment. This has the effect of rotating the pollution curve ec to the dashed curve ea. Assume this results in the violation of primary NAAQS in the year 1985, five years earlier than without the out-of-area pollution. This means an earlier curtailment of economic activity due directly to the long-range transport phenomenon.

The potential loss in economic product can be estimated by calculating the difference in economic output between (1) the projected increase in potential output possible under existing air quality regulations without additional background pollution from new out-of-area fossil fuel power plants, and (2) the projected increase in output possible when this additional source of pollution is taken into account.[7]

The following information is required for estimation of potential losses.

(1) The pattern of economic growth by industry in the Columbus SMSA and its projected impact on local ambient air quality.

(2) The effect of emissions from out-of-area sources on ambient air quality in the Columbus SMSA area.

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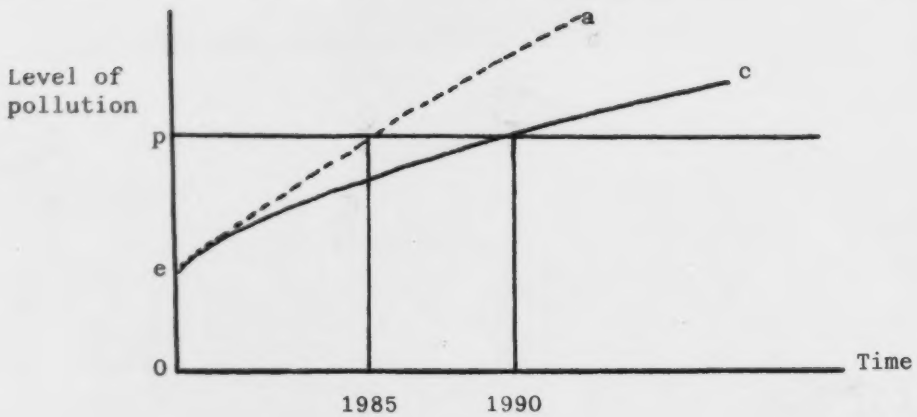

Figure 3. Estimation of Economic Loss Due to Out-of-Area Air Pollution

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(3) Estimating the effect of these increases in ambient air pollution on projected economic growth and employment in the Columbus SMSA under the constraints of the provisions of the Clean Air Act.

These steps are discussed in detail in the sections that follow. The next section presents some background information concerning the problems of fossil fuel pollution, the general problem of the long-range transport of air pollution, and a summary of the pertinent air pollution regulations.

With the above information, we are able to estimate potential dollar and employment losses to the Columbus SMSA from premature violation of primary air standards associated with out-of-area point sources. The reader is cautioned that such estimates are only potential losses and probably represent an upper bound on losses. We do not know how strictly air standards will be enforced. Consequently, we treat the standards as though they were fully enforced.

We provide estimated losses for seven different ORBES scenarios. Scenario 2 is a "business-as-usual" case with respect to economic and energy/fuel growth rates in the ORBES region and assumes compliance with existing State Implementation Plans (SIPs) as well as New Source Performance Standards (NSPS) and Revised New Source Performance Standards (RNSPS). Scenario 1 is identical to scenario 2 except it is assumed there is no compliance with SIPs. Scenario 7 is identical to scenario 2 except a 45-year utility plant life is assumed (35-year in the case of scenario 2) and the rate of growth in demand for electricity is substantially higher. In scenario 2d, non-compliance with SIPs is assumed.

In all other respects, scenarios 2 and 2d are identical. Scenario 4 represents a regional shift toward natural gas use and results in a somewhat lower demand for electricity by 2000 than found in scenario 2. Scenarios 7a and 7b are variants of scenario 7: 7a uses a dispatching algorithm based on least emissions rather than least cost while 7b assumes a 35-year utility plant life. In all other respects, 7a and 7b are identical to 7.[8]

Results reported in the main body of the text reflect contributions to Columbus SMSA TSP readings from both utility sources and industrial background from out-of-area (the latter are assumed constant throughout the time period). Out-of-area industrial contributions were estimated for us by Teknekron Research, Inc., at 2 $\mu g/m^3$. As an "experiment," we also calculated the potential economic losses to the Columbus SMSA without out-of-area industrial background. The results of these calculations are reported in Appendix C and should be interpreted in the same manner as the main text results. One way to view these results is as an answer to the following question: What are the potential losses to the Columbus SMSA from out-of-area sources if non-utility sources were reduced to 0? The reported results, of course, isolate that portion of losses uniquely attributable to scenario specifications concerning utility growth, compliance with SIPs, etc.

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SECTION 2

ECONOMIC GROWTH PROJECTIONS FOR THE COLUMBUS SMSA

Regional growth projections may be based on a variety of modeling techniques ranging in complexity from linear extrapolation of past growth to dynamic control models.[9] The choice of model type is dictated by available resources, data, and the questions to be answered using the model. In this work, available resources largely dictated the type of economic model used for regional growth projections. We use trend extrapolation of gross regional product (GRP) to derive our Columbus SMSA economic projections. GRP represents the market value of final goods and services produced in a region during a given time period. Since GRP does not contain a foreign trade sector, it is analogous to the gross domestic product. GRP is basically a value-added concept in that it is inclusive of capital consumption allowances, but not of the value of intermediate products used in the production of goods and services.[10]

The Columbus SMSA has many characteristics which make it an ideal area for estimating gross regional product. It is located in the center of Ohio and is relatively isolated from other urban areas. There is very little commuting to and from the SMSA so that personal income by place of work and by place of residence are almost identical.

According to Kendrick and Jaycox, there are three basic approaches to gross regional product estimation.[11] These are the following:

(1) Gross expenditure by sector: According to this approach, GRP is defined as the sum of personal consumption expenditures, gross private investment, net regional exports, and government purchases.

(2) Gross income by type: This is a factor share approach in which GRP is defined as the sum of payments to labor, proprietor's income, rents, royalties, net interest, inventory valuation adjustments, corporate profits, indirect business taxes, business transfer payments, and capital consumption allowances, minus net subsidies.

(3) Gross product by sector and industry: According to this approach, GRP is the sum of the value added in production in each industry.

The method described by Kendrick and Jaycox is a combination of methods (2) and (3) above, and is the approach used in this study. This method has been widely used in regional analysis.[12] It involves the estimation of the value added for the following major economic categories: government, farm, private non-farm, mining, construction, manufacturing, trade, finance-insurance-real estate (FIRE), transportation-communication-utilities (TCU), and services.

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Gross product originating (GPO) in each major industry category is estimated separately.[13]

Government: Gross government product is defined as the compensation of general government employees, which is composed of wages and salaries plus supplements. The wage and salary portion is available annually, by state, in the August issues of Survey of Current Business. The supplement portion is estimated by multiplying the state wage and salary figure by the national ratio of compensation of United States civilian government employees to the earnings of United States civilian government employees.[14] This is equivalent to the Kendrick-Jaycox method of estimating the supplement portion by multiplying the state wage and salary figures by the national ratio of supplements to wages and salaries for each year to the state government wage and salary figure.

Following Bulent, gross state government product is defined as follows:

$$GRG_t = USCG_t/USEG_t \times EG_t$$

where GRG = gross state government product
USCG = compensation of United States government employees
USEG = earnings of United States government employees
EG = earnings of civilian government employees in the state.
t = time

The above procedure can be applied at the SMSA level if SMSA government wage and salary data is available. Unfortunately, such information is not readily available for Columbus. The procedure used here is to multiply the state gross government product figure by the ratio of Columbus government employment to Ohio government employment.[15] The results of these calculations are shown in Table 1.

Farm: Data needed to calculate state gross farm product is available in the annual supplement to the August issues of Farm Income Situation (after 1975 the title is Farm Income Statistics) published by the U.S. Department of Agriculture.

Gross farm product originating is calculated as follows:

Credits: Cash receipts from marketing, value of home consumption, gross rental value of dwellings, net change in inventories.

Debits: Feed, livestock, seed, fertilizer, repairs and operation of equipment, miscellaneous operating expenses, net rent to non-farm landlords.

Total gross farm product is equal to credits minus debits. Since the necessary data to directly calculate gross farm product at the SMSA level is not available, it was assumed that gross farm product originating in the Columbus SMSA is proportional to Ohio gross farm product. The factor used as a proxy in this estimation is the ratio (calculated for each year) of Columbus SMSA cash receipts from marketing to Ohio cash receipts from marketing.

$$GRFP_t = CCR_t/OCR_t \times OGFP_t$$

TABLE 1. COLUMBUS SMSA GROSS GOVERNMENT PRODUCT

Year	(a) Ohio Gross government product*	(b) Ratio of Columbus government employment to Ohio government employment	(c) Columbus gross government product (axb)
1960	1888.6	.122	230.4
1961	2060.4	.127	261.7
1962	2146.4	.131	281.2
1963	2253.8	.130	293.0
1964	2488.9	.144	358.4
1965	2665.6	.146	389.2
1966	2924.9	.147	430.0
1967	3147.8	.148	465.9
1968	3571.3	.147	525.0
1969	3914.6	.148	579.4
1970	4395.2	.149	654.9
1971	4837.3	.149	720.8
1972	5325.3	.151	804.1
1973	5939.3	.150	890.9
1974	6422.6	.152	976.2
1975	7089.4	.151	1070.5
1976	7804.9	.151	1178.5

SOURCE (for column b): Employment and Earnings, States and Areas 1939-75, U.S. Department of Labor, Bureau of Labor Statistics, Washington, D.C., 1977.

*See Appendix A, Table A-1.

where CCR = Columbus SMSA cash receipts from marketing
OCR = Ohio cash receipts from marketing
OGFP = Ohio gross farm product
t = time

The results of these calculations are given in Table 2.

Private Non-farm: The Kendrick-Jaycox method for calculating gross state product for industries in the private non-farm sector involves the application of national coefficients to available state data. The national coefficients can be calculated from the Department of Commerce estimates of gross national product (GNP) by major industry.[16] The basis for calculating gross state product for the non-farm secotr is income received by persons for participation in current production. This income includes wages and salary disbursements, other labor income, and proprietor's income.

State income originating by industry is calculated by using the national ratio of income originating to income received. The same procedure is used to estimate capital consumption allowances and indirect business taxes for each industry. The following formulas describe these calculations:

$$YO^i_n/YR^i_n \cdot YR^i_s = YO^i_s$$

$$KC^i_n/YO^i_n \cdot YO^i_s = KC^i_s$$

$$IBT^i_n/YO^i_n \cdot YO^i_s = IBT^i_s$$

where YO = income originating
YR = income received
KC = capital consumption allowances
IBT = indirect business taxes
i = industry i
n = nation
s = state

The sum of these three components yields gross product originating in industry i for the particular state in a given year.

$$YO^i_s + KC^i_s + IBT^i_s = GPO^i_s$$

Albert Niemi[17] has developed a method for adjusting the estimate of gross product originating in manufacturing to eliminate any bias introduced by the implicit assumption of similar factor proportions. The adjustment factor is calculated from state manufacturing value-added data and labor payroll data published by the U.S. Department of Commerce in the Annual Survey of Manufactures. Value added per dollar of labor payroll in the state is compared to value added per dollar of labor payroll in the nation:

$$VA_s/LP_s + VA_n/LP_n$$

Multiplying this calculation by the unadjusted estimate of gross state product (GSP) originating in manufacturing yields the adjusted estimate of gross

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TABLE 2. COLUMBUS SMSA GROSS FARM PRODUCT

Year	(a) Columbus SMSA Cash Receipts	(b) Ohio cash receipts	(c) a ÷ b	(d) Ohio GFP	(e) Columbus GFP (cxd)
1960	72.008	1003.775	.0717	636.8	45.66
1961	82.130	1045.359	.0786	635.4	49.94
1962	80.083	1038.822	.0771	614.3	47.36
1963	80.695	1060.102	.0761	616.4	46.91
1964	75.682	1058.768	.0715	604.8	43.24
1965	80.160	1113.372	.0720	652.4	46.97
1966	94.718	1301.819	.0728	808.5	58.86
1967	90.986	1234.297	.0737	680.5	50.15
1968	88.636	1233.580	.0719	769.8	55.35
1969	92.423	1253.822	.0737	794.3	58.54
1970	96.705	1323.493	.0731	787.2	57.54
1971	99.801	1415.405	.0705	828.3	58.04
1972	117.095	1656.732	.0707	929.3	65.70
1973	153.049	2267.056	.0675	1386.7	93.60
1974	172.970	2505.882	.0690	1460.4	100.77
1975	192.894	2614.159	.0738	1610.6	118.86
1976	203.653	2765.277	.0736	1661.2	122.26

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manufacturing product (see Table A-5 in Appendix A). Finally, all of these calculations and adjustments give the estimate of gross state product originating in the private non-farm sector. These calculations, for the years 1962-1979, for Ohio are given in Tables A-6 through A-20 in Appendix A.

To get an approximation of the Columbus SMSA gross product originating in the private non-farm sector, the state estimate of gross product for each sector was multiplied by the ratio of Columbus SMSA payroll for that sector divided by total state payroll for that sector for each year considered. Payroll information by industry is available for every year since 1962 in the City and County Data Book published by the U.S. Department of Commerce. The Columbus SMSA private non-farm factors are given in Table A-4 in Appendix A. Table 3, on the following page, shows the results of the calculations of Columbus SMSA gross product for the years 1962-1976.

Estimation of Gross Manufacturing Product by Industry

A shortcoming of the Kendrick-Jaycox method for calculating gross manufacturing product is that it does not allow for the estimation of the product of the various manufacturing sector industries. A single value for gross product originating in manufacturing reveals relatively little about the economic base of a state or region. The method described below allows the calculation of gross manufacturing product for states of SMSAs at the two-digit Standard Industrial Classification (SIC) code level.[18]

The basis of the method is industry value-added information reported in the Annual Survey of Manufactures. Value added is not equivalent to gross product originating. Value added for a particular industry is comprised of the total value of output for that industry minus the cost of purchased materials. Since the cost of purchased materials excludes costs of personal business services, the value-added figure is, in the case of most industries, larger than the corresponding gross product originating figure.

Theoretically, value added should be a broader measure of economic activity than the personal income data used in the Kendrick-Jaycox approach. Value added reflects the productive factor of capital as well as labor, while personal income reflects only the primary labor component.

The procedure used to estimate gross product originating in manufacturing is to adjust area value-added figures by the national ratio of gross national product to value added by industry:

$$VA_r^i \cdot (GPO/VA)_n^i = GPO_r^i$$

where VA = value added
GPO = gross product originating
i = ith manufacturing industry
n = nation
r = region

National, state, and SMSA data for value added by manufacturing is available in the Annual Survey of Manufactures. Gross product originating in manufacturing, as a whole, is available in various issues of the Survey of

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TABLE 3. COLUMBUS SMSA GROSS URBAN PRODUCT

(millions of current dollars)

	1962	1963	1964	1965	1966
Mining	11.65	11.61	12.57	12.25	12.01
Construction	137.90	142.20	148.90	163.42	189.34
Trade	481.10	512.89	560.43	609.00	657.42
Finance, Insurance, Real Estate	469.36	485.51	553.58	590.45	628.96
Transportation, Communication, Utilities	279.97	255.54	319.96	312.46	333.76
Services	345.23	369.76	366.73	410.10	429.05
Manufacturing	819.19	889.62	953.77	989.86	1066.11
Government	281.18	292.99	358.40	389.18	439.96
Farm	47.36	46.91	43.24	46.97	58.86
TOTAL	2872.94	3007.03	3317.58	3523.69	3815.47

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TABLE 3 (continued)

	1967	1968	1969	1970	1971
Mining	11.84	12.07	14.69	13.72	12.03
Construction	204.94	271.44	291.39	251.50	290.85
Trade	718.24	796.32	879.04	958.00	1047.68
Finance, Insurance, Real Estate	705.17	749.08	789.42	946.43	1090.57
Transportation, Communication, Utilities	356.39	371.83	416.21	442.36	528.28
Services	482.47	544.50	594.34	684.13	734.64
Manufacturing	1046.68	1164.35	1321.21	1341.42	1420.14
Government	465.87	524.98	597.36	654.88	720.76
Farm	50.15	55.35	58.54	57.54	58.04
TOTAL	4041.75	4489.92	4962.20	5349.98	5902.99

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TABLE 3 (continued)

	1972	1973	1974	1975	1976
Mining	15.34	15.78	23.04	27.49	29.78
Construction	344.50	388.38	366.81	349.09	344.08
Trade	1137.48	1262.76	1459.45	1612.50	1779.19
Finance, Insurance, Real Estate	1207.82	1345.66	1401.77	1489.77	1661.83
Transportation, Communication, Utilities	617.84	625.43	699.97	796.62	838.85
Services	808.11	877.35	958.72	1033.15	1229.47
Manufacturing	1586.21	1755.71	1869.30	1900.31	2042.50
Government	804.12	890.90	976.24	1070.50	1178.54
Farm	65.70	93.60	100.77	118.86	122.26
TOTAL	6587.12	7255.57	7856.07	8398.29	9226.50

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Current Business.

Unfortunately, the national gross product/value-added ratio is harder to calculate at the two-digit SIC level. While national and regional value-added data is available at this level, gross product originating must be built up from national income originating data. It is assumed that gross product originating in a particular sector is equal to national income originating in that sector plus that sector's total indirect business taxes and capital consumption allowances. The relatively minor portions of GPO of business transfer payments (in 1976 these accounted for less than .5 percent of GNP) and subsidies less current surplus of government enterprises (in 1976 less than .05 percent of GNP) are ignored here.

National income originating data is available at the two-digit SIC level in various July issues of the Survey of Current Business. Although capital consumption and indirect business tax data is unavailable at the two-digit SIC level, it is available annually for durable and non-durable goods. These figures were apportioned to each manufacturing industry according to the proportion of national income of each industry to the total national income of the appropriate (durable or non-durable) manufacturing category.

The results of these calculations for the Columbus SMSA are given in Table 4 for the years 1972-76. Prior to 1972, the census definition for the Columbus SMSA did not include the counties of Madison and Pickaway. Therefore, the value-added data reported in the Annual Survey of Manufactures prior to 1972 is not equivalent to value-added data for later years. For this reason, it was impossible to calculate manufacturing value added prior to 1972.

Implications of Kendrick-Jaycox Assumptions

As explained above, national ratios of income originating to income received in various industries are used to obtain estimates of state gross product. This assumption implies that within major industries factor proportions are similar or that the production function is of the CES variety.[19] Niemi attempts to get away from this assumption in manufacturing by adjusting for differences in the output labor ratio. In a recent article,[20] Niemi examined the appropriateness of the assumption that manufacturing proportions were similar in all states. He detected differences sufficient enough to suggest that caution be used in making the assumption of similar factor proportions. However, Niemi points out that this bias in manufacturing can be adjusted and theoretically the bias should be less significant in non-manufacturing industries which have relatively high labor inputs and in the services industries. Most of the private non-farm sectors (except mining) fall into one of these categories. Furthermore, tests conducted for the years 1950, 1955, 1960, and 1965 show that Ohio is particularly representative of the national output-labor ratio.

Constant Dollar Estimates

In order to make meaningful statements about past economic growth and to make accurate economic projections, the calculations of gross regional product

TABLE 4. COLUMBUS SMSA GROSS MANUFACTURING PRODUCT

(millions of current dollars)

SIC category	1972	1973	1974	1975	1976
20 Food & kindred products	180.5	219.6	255.5	283.2	319.4
27 Printing & publishing	106.9	115.1	117.4	125.0	153.2
28 Chemicals & allied products	54.5	57.9	55.4	55.5	68.6
30 Rubber, miscellaneous plastics	72.4	77.1	83.7	95.7	130.1
32 Stone, clay & glass	172.9	187.4	183.5	197.6	255.2
33 Primary metal industries	45.6	56.2	66.2	82.6	70.6
34 Fabricated metal products	173.1	261.8	215.6	220.9	297.5
35 Machinery, except electrical	184.3	181.3	196.2	253.7	240.3
36 Electric, electronic equipment	291.4	255.6	263.3	241.7	242.9
37 Transportation equipment	114.4	118.4	90.1	99.7	137.7
38 Instruments, related products	55.5	80.2	83.6	56.6	56.9
Other	183.2	155.8	146.1	70.7	62.7
SMSA TOTAL	1634.7	1766.4	1756.6	1782.9	2035.1

must be in terms of constant dollars. For the farm and the private non-farm sectors, these adjustments were made by using the implicit price deflators (1972 = 100) published by the U.S. Department of Commerce.[21]

Gross government product is deflated according to the procedure recommended by the Commerce Department. Average compensation per government employee is used to deflate government product:

$$(N_g/LP_g)^t/(N_g/LP_g)\ 1972\ X\ GGP = GGP/P$$

where GGP = gross government product in current dollars
N_g = government employment
LP_g = compensation of government employees
GGP/P = real gross government product

These results are presented in Table 5.

Economic Growth Projections

The projection of economic growth for the Columbus SMSA is accomplished through a statistical procedure using least squares on historic gross product data for the region. In order to estimate high and low growth projections for the Columbus area, a statistical computer package was used to obtain a confidence interval for Columbus GSP projections by sector. Assuming that the projected parameter $\hat{\theta}$ is normally distributed with an expected value of 0 and variance, σ^2_{θ}, the confidence interval for θ with a confidence coefficient equal to (1-d) can be obtained using the following formula:

$$\text{lower confidence interval} = \hat{\theta} - Z_{\alpha/2}\ \sigma_{\hat{\theta}}$$

$$\text{upper confidence interval} = \hat{\theta} + Z_{\alpha/2}\ \sigma_{\hat{\theta}}$$

where $Z = \hat{\theta} - \theta\ /\sigma_{\hat{\theta}}$ has a standard normal distribution. The analysis reported in the following pages treats the high economic growth case for the Columbus SMSA. It will be noted that the confidence intervals for the mining and construction sectors are quite large. This is due to the volatility of these sectors in the historical period. This is not a serious problem, however, due to the fact that these sectors represent a relatively small portion of GRP and they are not sectors which produce a significant amount of air pollution.

In order to project economic growth within the manufacturing sector, the following procedure was used. SAS projections were made of Table 4 to the year 2000. The percentage contribution of each two-digit industry to total manufacturing was then calculated for the year 2000. These percentages were then applied to the projected high- and low- total manufacturing output projections (Table 6) to give high- and low- growth projections by two-digit SIC code for the year 2000. Average annual compound growth rates between the years 1976 and 2000 were then calculated for each manufacturing sector and for total manufacturing output. Applying these growth rates to the 1976 two-digit SIC estimates (1972 dollars) allows an estimation of manufacturing output by two-digit SIC between the years 1977 and 2000.

TABLE 5. COLUMBUS SMSA GROSS URBAN PRODUCT

(1972 = 100)
(millions of dollars)

	1962	1963	1964	1965	1966
Mining	13.56	13.84	14.95	14.94	14.66
Construction	262.67	261.88	271.22	286.70	314.52
Trade	660.85	699.71	745.25	802.37	847.19
Finance, Insurance, Real Estate	686.20	670.59	743.06	785.17	798.17
Transportation, Communication, Utilities	338.91	309.00	355.95	374.83	401.25
Services	545.39	568.86	544.92	586.70	584.54
Manufacturing	968.31	1075.72	1151.90	1185.46	1254.25
Government	551.33	547.64	635.46	661.87	716.55
Farm	68.24	68.48	65.42	64.34	73.12
TOTAL	4095.46	4215.72	4528.13	4762.38	5004.25

(continued)

TABLE 5 (continued)

	1967	1968	1969	1970	1971
Mining	14.23	14.27	17.00	15.00	13.10
Construction	328.43	416.96	389.04	298.69	316.49
Trade	885.62	939.06	974.55	1021.32	1070.15
Finance, Insurance, Real Estate	867.37	887.54	904.26	1030.97	1131.30
Transportation, Communication, Utilities	421.81	439.31	479.45	493.21	554.86
Services	626.04	669.74	687.89	751.79	761.28
Manufacturing	1201.70	1292.29	1432.98	1395.86	1434.48
Government	721.16	749.97	772.48	784.29	789.44
Farm	67.07	71.98	69.61	69.08	68.85
TOTAL	5133.43	5481.12	5727.26	5860.21	6139.95

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TABLE 5 (continued)

	1972	1973	1974	1975	1976
Mining	15.34	13.98	13.75	13.57	13.54
Construction	344.50	349.89	303.65	256.87	248.43
Trade	1137.48	1189.04	1233.69	1239.43	1307.27
Finance, Insurance, Real Estate	1207.82	1291.42	1299.14	1280.97	1364.39
Transportation, Communication, Utilities	617.84	603.81	644.12	670.44	653.46
Services	808.11	832.40	837.31	807.15	896.77
Manufacturing	1586.21	1709.55	1631.15	1503.41	1536.87
Government	804.12	831.84	851.87	861.22	882.80
Farm	65.70	61.62	67.54	81.41	83.91
TOTAL	6587.12	6883.55	6882.22	6714.47	6987.44

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TABLE 6. HIGH AND LOW GROWTH PROJECTIONS FOR THE COLUMBUS SMSA
(millions of 1972 dollars)

	1977		1978		1979		1980	
	Low	High	Low	High	Low	High	Low	High
Mining	12.05	16.08	11.96	16.09	11.87	16.10	11.78	16.11
Construction	213.48	419.82	211.93	423.04	210.15	426.48	208.17	430.13
Trade	1333.69	1380.47	1379.85	1427.71	1425.95	1475.00	1472.00	1522.33
Finance, Insurance, Real Estate	1330.53	1526.32	1382.24	1582.57	1433.75	1639.03	1485.07	1695.68
Transportation, Communication, Utilities	633.76	757.18	690.16	785.75	716.47	814.42	742.69	843.18
Services	857.49	964.17	882.51	991.67	907.42	1019.27	932.22	1046.98
Manufacturing	1547.64	1887.26	1588.71	1936.21	1629.43	1985.51	1669.82	2035.16
Government	871.51	982.32	893.07	1006.46	914.52	1030.70	935.85	1055.06
Farm	63.26	85.70	63.59	86.55	63.90	87.42	64.19	88.32
TOTAL	6893.41	8019.32	7104.02	8256.05	7313.46	8493.93	7521.79	8732.95

(continued)

TABLE 6 (continued)

	1981		1982		1983		1984	
	Low	High	Low	High	Low	High	Low	High
Mining	11.68	16.13	11.58	16.16	11.47	16.18	11.37	16.21
Construction	206.00	433.96	203.66	437.97	201.16	442.13	198.51	446.45
Trade	1518.02	1569.70	1563.99	1617.12	1609.93	1664.57	1655.84	1712.05
Finance, Insurance, Real Estate	1536.20	1752.51	1587.17	1809.50	1637.99	1866.65	1688.67	1923.94
Transportation, Communication, Utilities	768.82	872.03	794.87	900.95	820.85	929.95	846.76	959.02
Services	956.92	1074.78	981.53	1102.68	1006.06	1130.66	1030.52	1158.72
Manufacturing	1709.89	2085.11	1749.68	2135.35	1789.21	2185.85	1828.49	2236.59
Government	957.09	1079.52	978.23	1104.07	999.29	1128.71	1020.27	1153.43
Farm	64.45	89.24	64.70	90.18	64.92	91.13	65.14	92.10
TOTAL	7729.07	8972.98	7935.41	9213.98	8140.88	9455.83	8345.57	9698.51

(continued)

TABLE 6 (continued)

	1985		1986		1987		1988	
	Low	High	Low	High	Low	High	Low	High
Mining	11.26	16.24	11.14	16.27	11.03	16.31	10.91	16.35
Construction	195.72	450.89	192.81	455.47	189.79	460.15	186.66	464.94
Trade	1701.71	1759.56	1747.56	1807.11	1793.38	1854.67	1839.17	1902.27
Finance, Insurance, Real Estate	1739.22	1981.35	1789.66	2038.88	1839.98	2096.52	1890.21	2154.26
Transportation, Communication, Utilities	872.61	988.15	898.41	1017.33	924.15	1046.56	949.85	1075.85
Services	1054.90	1186.84	1079.23	1215.03	1103.49	1243.28	1127.70	1271.58
Manufacturing	1867.55	2287.56	1906.40	2338.73	1945.07	2390.09	1983.57	2441.61
Government	1041.17	1178.22	1062.01	1203.08	1082.79	1227.99	1103.51	1252.97
Farm	65.33	93.08	65.52	94.08	65.69	95.09	65.85	96.11
TOTAL	8549.47	9941.89	8752.74	10185.98	8955.37	10430.66	9157.43	10675.94

(continued)

TABLE 6 (continued)

	1989		1990		1991		1992	
	Low	High	Low	High	Low	High	Low	High
Mining	10.79	16.39	10.67	16.43	10.56	16.47	10.43	16.52
Construction	183.44	469.83	180.13	474.80	176.74	479.86	173.28	484.99
Trade	1884.95	1949.88	1930.70	1997.51	1976.44	2045.16	2022.16	2092.83
Finance, Insurance, Real Estate	1940.34	2212.09	1990.40	2270.01	2040.37	2328.00	2090.28	2386.05
Transportation, Communication, Utilities	975.51	1105.17	1001.12	1134.53	1026.70	1163.94	1052.24	1193.37
Services	1151.85	1299.93	1175.97	1328.32	1200.04	1356.76	1224.07	1385.24
Manufacturing	2021.91	2493.30	2060.11	2545.13	2098.17	2597.09	2136.11	2649.18
Government	1124.18	1278.00	1144.80	1303.06	1165.38	1328.18	1185.92	1353.33
Farm	66.00	97.14	66.14	98.19	66.27	99.24	66.39	100.29
TOTAL	9358.97	10921.73	9560.04	11167.98	9760.67	11414.70	9960.88	11661.80

(continued)

TABLE 6 (continued)

	1993		1994		1995		1996	
	Low	High	Low	High	Low	High	Low	High
Mining	10.30	16.56	10.17	16.61	10.05	16.66	9.92	16.71
Construction	169.75	490.18	166.15	495.44	162.50	500.76	158.79	506.13
Trade	2067.86	2140.51	2113.55	2188.21	2159.92	2235.92	2204.90	2283.65
Finance, Insurance, Real Estate	2140.12	2444.18	2189.91	2502.36	2239.63	2560.60	2289.31	2618.89
Transportation, Communication, Utilities	1077.76	1222.84	1103.24	1252.33	1128.70	1281.85	1154.13	1311.39
Services	1248.07	1413.75	1272.04	1442.30	1295.97	1470.87	1319.88	1499.47
Manufacturing	2173.94	2701.37	2211.67	2753.67	2249.30	2806.07	2286.85	2858.55
Government	1206.43	1378.52	1226.90	1403.75	1247.33	1429.01	1267.75	1454.29
Farm	66.51	101.36	66.62	102.43	66.72	103.51	66.82	104.59
TOTAL	10160.74	11909.27	10360.25	12157.10	10559.43	12405.25	10758.35	12653.67

(continued)

TABLE 6 (continued)

	1997		1998		1999		2000	
	Low	High	Low	High	Low	High	Low	High
Mining	9.79	16.76	9.66	16.81	9.53	16.86	9.40	16.91
Construction	155.04	511.54	151.24	517.01	147.40	522.51	143.52	528.06
Trade	2250.55	2331.38	2296.19	2379.12	2341.83	2426.88	2387.45	2474.64
Finance, Insurance, Real Estate	2338.94	2677.22	2388.53	2735.60	2438.08	2794.02	2487.59	2852.48
Transportation, Communication, Utilities	1179.55	1340.96	1204.94	1370.54	1230.31	1400.15	1255.67	1429.77
Services	1343.77	1528.10	1367.63	1556.75	1391.47	1585.42	1415.28	1614.11
Manufacturing	2324.31	2911.11	2361.70	2963.75	2399.02	3016.46	2436.27	3069.23
Government	1288.13	1479.60	1308.49	1504.94	1328.83	1530.29	1349.14	1555.67
Farm	66.91	105.68	67.00	106.78	67.08	107.88	67.16	108.98
TOTAL	10956.99	12902.35	11155.38	13151.30	11353.55	13400.47	11551.48	13640.85

SECTION 3

THE IMPACT OF LOCAL ECONOMIC GROWTH ON COLUMBUS SMSA AMBIENT AIR QUALITY

The state of Ohio has formally adopted the Federal Ambient Air Quality Standards for SO_2 and particulates. In the city of Columbus, the limiting pollutant is particulate matter. Table 7 provides the 1976 readings for Columbus, Ohio. Several of the air pollution monitors in the Columbus SMSA show levels of total suspended particulates (TSP) above that permitted under the National Ambient Air Quality Standards (NAAQS). Annual SO_2 levels are well below NAAQS limits.

Although the PSD requirements have obvious significance in view of the long-range transport phenomenon, National Ambient Air Quality Standards, rather than PSD standards, will be examined here as the factor limiting economic growth. There are several problems with using PSD increments as an economic growth limitor. First of all, modeling for PSD is site specific. It is impossible to say whether or not growth will stop in an area even if some of the monitors exceed the estimated allowable limit. The PSD calculations depend upon the modeling technique applied. Also, the concept of the "baseline" level of pollution may vary from monitor to monitor because it is modeled on a case by case basis. Many important sources, such as some coal-fired power plants and industries which have converted from oil to coal use, are exempt from the baseline calculation. Under the NAAQS, the baseline is simply the existing level of pollution in the year chosen. Thus, neither the baseline pollution levels nor the permitted levels are ambiguous in the case of the NAAQS. Most importantly, TSP levels in Columbus are high enough to impose growth constraints under the NAAQS by the year 2000.

For this analysis, average annual concentrations rather than maximum 24-hour levels are used. There are several reasons why it is preferable to use the annual standards. First of all, the annual standard is much less susceptible to unusual fluctuations in air quality. The maximum 24-hour readings, even when the second highest measured levels are used, are quite sensitive to out-of-the-ordinary meteorological conditions. TSP readings are particularly sensitive to fluctuations due to fugitive dust from construction projects and other such localized events. In addition to avoiding these problems, average annual concentrations are more logically applied to the method of analysis used below. Average annual concentrations are much more similar over the various monitoring sites in the Columbus area than are the 24-hour readings, thus making it more reasonable to average them in order to obtain a single reading for the region.

In order to determine the effect of economic growth on ambient air

TABLE 7. 1976 SO_2 AND TSP READINGS FOR COLUMBUS, OHIO
(ug/m^3)

SO_2		Suspended particulates	
Arithmetic mean	Maximum 24-hour (2nd highest)	Geometric mean	Maximum 24-hour (2nd highest)
31	74	85*	238*
24	81	71/	133
31	82	92*	204/
73	223	70/	168/
14	52	91*	226/
7	42	50	108
44	189	64/	138
31	128	42	46
25	84	62/	110
13	53	52	90
16	33	65/	135
12	50	60/	119
11	22	48	94
11	37	60/	150/
Average 24.5	82.1	65.1	139.9

SOURCE: Air Quality Data - 1976 Annual Statistics, Office of Air Quality Planning and Statistics, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1978.

* Violates primary standard.

/ Violates secondary standard.

quality, a procedure is needed for isolating the local contribution to area air pollution. That is, we need to isolate that portion of ambient air pollution due to local economic activity. In order to do this, the assumption is made that the major out-of-area contributor to TSP levels in Columbus is sulfate pollution from coal-fired electricity generating facilities in the Ohio River Valley upwind from Columbus. Sulfates are fine particulates and, as such, are a component of the total TSP readings. The sulfate (MSO_4) level is used as a tracer to determine the contribution of the long-range transport of air pollution from coal-fired power plants to air pollution in Columbus.[22] Studies conducted in connection with the Ohio River Basin Energy Study (ORBES) project have demonstrated the validity of this approach.[23] A major finding of the ORBES work was that days when excessive TSP readings occurred in the Monongahela Valley of Pennsylvania were associated with long-range transport conditions. Monitors showing violations of annual TSP standards had a large number of days on which the MSO_4/TSP ratio was 0.10 or greater. Furthermore, these days were correlated with meterological conditions conducive to long-range transport from the Ohio Valley. Long-range transport conditions were present on 38 percent of the days on which the 24-hour TSP standard was exceeded. Also, two of the three years in which the TSP secondary standard was exceeded occurred when annual sulfate levels were greater than 12.0 ug/m^3. These findings were interpreted to mean that the long-range transport of sulfate constituted a significant percentage of TSP levels at these sites.

The assumption that MSO_4 in the Columbus area originates primarily from coal-fired power plants is reasonable since these plants are the only major contributors of sulfate upwind from Columbus. Since sulfur dioxide is converted into sulfate at a fairly slow rate, SO_2 emissions within the Columbus area will not significantly affect sulfate readings there. Prevailing winds will carry the SO_2 emissions away from Columbus before it is converted into MSO_4. An advantage of using MSO_4 as a tracer for coal-fired power plant emissions is that sulfate readings are fairly uniform over the Columbus area, thereby lending credibility to the area approach applied in this study.

Emission data obtained from the Ohio Environmental Protection Agency was used to determine actual emissions in the Columbus SMSA for the year 1976. These are reported in Table 8. These emissions data are used in conjunction with the industrial gross product data estimated in Section 2 to calculate pollution generated in Columbus due to local economic growth. Emissions were then translated into estimates of ambient air quality by applying the following ratio:

$$\text{1976 ambient air quality/1976 emissions} =$$

$$\text{ambient air quality in year t/year t emissions}$$

As mentioned above, MSO_4 readings in Columbus were assumed to be an indication of the amount of total TSP pollution attributable to long-range transport of air pollution from coal-fired power plants and industrial sources upwind of the Columbus SMSA.[24] In order to determine the contribution to TSP attributable to local sources, Columbus MSO_4 levels in 1976 were subtracted from average total TSP readings in the Columbus area for that year. The sulfate reading in the Columbus area, 1976, was 10 ug/m^3 (8 from utility and 2 from non-utility out-of-area sources).[25] Total TSP readings (average of

TABLE 8. 1976 TSP SOURCE EMISSIONS (ACTUAL) COLUMBUS SMSA

(tons)

SIC category		TSP	SO_2
20	Food & kindred products	331.2	1592.8
28	Chemicals & allied products	107.9	0.0
32	Stone, clay & glass	1084.7	8.8
33	Primary metal industries	1146.6	1856.6
34	Fabricated metal products	212.3	797.2
35	Machinery, except electrical	346.7	1790.3
36	Electrical, electronic equipment	0.0	0.0
37	Transportation euqipment	39.3	1434.4
	Other	4232.2	9513.7
Total industrial		7500.1	16993.8
Non-industrial		29376.9	33268.2
Mobile sources		4404.4	

SOURCE: Ohio Environmental Protection Agency.

Columbus area monitors) in the same year was 65.14 (ug/m^3).[26] The in-area contribution to TSP in 1976, then, was 55.14 ug/m^3. It is this figure that is used as the base level in order to project local pollution due to economic growth.

Contributions from local economic growth were divided into three components; industrial, non-industrial, and mobile sources. By assuming that each of these components contributed to ambient TSP levels in the same proportion as they contributed to total TSP emissions, the contribution to ambient TSP levels was calculated.

Sector	1976 Emissions Tons per Year	Ratio to Total Emissions	X	1976 Ambient TSP Level	=	Estimated Contribution to 1976 Ambient TSP Pollution
Manufacturing	7500.1	.18				9.93 ug/m^3
Non-Manufacturing	29376.9	.71		55.14		39.15 ug/m^3
Mobile	4464.4	.11				6.06 ug/m^3
Total	41342.0					

Each component's contribution to future ambient TSP pollution was calculated by applying the following compounded growth rates, 1976-2000, to the above estimates of each sector's 1976 contribution: manufacturing 2.9%, non-manufacturing 1.0%, and mobile 0%.

The manufacturing growth rate in emissions is assumed to be the same as the projected annual compound growth rate of gross product originating in manufacturing (Table B-2). Mobile emissions were projected to remain unchanged from their 1976 level. The reason for this assumption is that EPA emission standards for new automobiles will most likely offset the increase in emissions due to the growth in the number of registered vehicles. Non-industrial stationary emissions were projected to increase slightly. Adding industrial, non-industrial stationary emissions for a given year provides an estimate of total local emissions. Detailed results of these calculations are given in Table 9. It will be observed that violation of primary standards (75 ug/m^3) occurs in 2000 if the only source of pollution in Columbus was in-area and mobile sources. The reader is cautioned that the data reported in Table 9 exclude out-of-area contributions to Columbus SMSA TSP readings in the base period (1976) and every year thereafter.

TABLE 9. PROJECTED TSP LEVELS DUE TO COLUMBUS ECONOMIC GROWTH*
(ug/m^3)

Year	Sector/ Manufacturing	Non-Manufacturing	Mobile	Total
1976	9.9	39.2	6.1	55.2≠
1977	10.2	39.6	6.1	55.9
1978	10.5	40.0	6.1	56.6
1979	10.8	40.4	6.1	57.3
1980	11.1	40.8	6.1	58.0
1981	11.4	41.2	6.1	58.7
1982	11.8	41.6	6.1	59.5
1983	12.1	42.0	6.1	60.2
1984	12.5	42.5	6.1	61.1
1985	12.8	42.9	6.1	61.8
1986	13.2	43.3	6.1	62.6
1987	13.6	43.7	6.1	63.4
1988	14.0	44.2	6.1	64.3
1989	14.4	44.6	6.1	65.1
1990	14.8	45.1	6.1	66.0
1991	15.2	45.5	6.1	66.8
1992	15.6	46.0	6.1	67.7
1993	16.1	46.4	6.1	68.6
1994	16.6	46.9	6.1	69.6
1995	17.0	47.4	6.1	70.5
1996	17.5	47.8	6.1	71.4
1997	18.0	48.3	6.1	72.4
1998	18.5	48.8	6.1	73.4
1999	19.1	49.3	6.1	74.5
2000	19.6	49.8	6.1	75.5

(continued)

TABLE 9 (continued)

*Does not include background from out-of-area source in base year or thereafter.

/Sector shares based on percent of total TSP emissions originating in that sector, 1976.

‡Average of 1976 Columbus SMSA annual readings.

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SECTION 4

OUT-OF-AREA AND TOTAL CONTRIBUTIONS TO AMBIENT AIR QUALITY IN THE COLUMBUS SMSA

As noted earlier, out-of-area contributions to Columbus pollution levels are provided to us by Teknekron Research, Inc., under contract with the ORBES project.[27] The local-scale concentrations data are based on several other pieces of work in the ORBES project: estimated regional demand for electricity,[28] the siting patterns associated with anticipated demand levels,[29] the emissions of SO_2 from existing and additional generating units,[30] and finally the air quality modeling research[31] which converts the emission patterns into spatially identified concentrations. Table 10 contains the SO_4 concentrations in the Columbus SMSA due to outside sources for seven different scenarios. The industrial contribution is fixed at 2 ug/m^3 while utility contributions vary by scenario. The variation in 1985 and 2000 values for utility contribution is accounted for, of course, by the alternative conditions specified in scenarios: different growth rates, compliance or non-compliance with SIPs, alternative plant-life assumptions, etc. For our work, annual contributions are required. Because the emissions data used for the concentrations modeling are roughly linear over the two subperiods, we use linear interpolation to derive annual values.[32]

Table 11 contains the results of adding in-area, industrial out-of-area, and utility out-of-area projected concentrations. The last seven columns provide the totals for these three sources by scenario. Underlined values represent the first year in which primary standards are violated (75 ug/m^3). If the Columbus SMSA experienced no background from outside sources, violations would begin in 1998. Under scenarios 2, 4, 7a, and 7b, violations occur in 1992 when all sources are considered and in 1994 for scenario 1, 1987 for scenario 2d, and 1991 for scenario 7. Clearly, then, there will be potential economic losses in the Columbus SMSA for all seven scenarios when in-area and total out-of-area contributions are considered. Losses will be greatest in the case of scenario 2d and least for scenario 1. All other scenarios will have losses intermediate between the two extremes with scenarios 2, 4, 7a, and 7b having the same loss values.

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TABLE 10. REGIONAL SO_4 CONCENTRATIONS IN THE COLUMBUS SMSA DUE TO OUTSIDE SOURCES* (ug/m^3)

	1976	1985	2000
Scenario 1			
Industrial	2	2	2
Utility	8	4	3
Scenario 2			
Industrial	2	2	2
Utility	8	6	4
Scenario 2d			
Industrial	2	2	2
Utility	8	10	7
Scenario 4			
Industrial	2	2	2
Utility	8	6	4
Scenario 7			
Industrial	2	2	2
Utility	8	6	6
Scenario 7a			
Industrial	2	2	2
Utility	8	6	4
Scenario 7b			
Industrial	2	2	2
Utility	8	6	5

*Data provided by Teknekron Research, Inc., as reported in James J. Stukel, ed., Ohio River Basin Energy Study: Air Quality and Related Impacts, prepared for Office of Research and Development, U.S. Environmental Protection Agency (1980).

TABLE 11. PROJECTED TSP LEVELS IN THE COLUMBUS SMSA FROM ALL SOURCES, 1976-2000*

	in-area-only	with out-of-area industrial sources	with industrial and coal-fired power plant sources≠						
			1	2	2d	4	7	7a	7b
1976	55.2	57.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2
1977	55.9	57.9	65.5	65.7	66.1	65.7	65.7	65.7	65.7
1978	56.6	58.6	65.8	66.2	67.0	66.2	66.2	66.2	66.2
1979	57.3	59.3	66.1	66.7	67.9	66.7	66.7	66.7	66.7
1980	58.0	60.0	66.4	67.2	68.9	67.2	67.2	67.2	67.2
1981	58.7	60.7	66.7	67.7	69.8	67.7	67.7	67.7	67.7
1982	59.5	61.5	67.0	68.2	70.8	68.2	68.2	68.2	68.2
1983	60.2	62.2	67.3	68.7	71.8	68.7	68.7	68.7	68.7
1984	61.1	63.1	67.6	69.3	72.8	69.3	69.3	69.3	69.3
1985	61.8	63.8	67.8	69.8	73.8	69.8	69.8	69.8	69.8
1986	62.6	64.6	68.6	70.5	74.5	70.5	70.6	70.5	70.6
1987	63.4	65.4	69.4	71.3	75.1	71.3	71.5	71.3	71.4
1988	64.3	66.3	70.2	72.0	75.8	72.0	72.3	72.0	72.2
1989	65.1	67.1	71.0	72.7	76.5	72.7	73.2	72.7	73.0
1990	66.0	68.0	71.8	73.5	77.2	73.5	74.1	73.5	73.8
1991	66.8	68.8	72.6	74.3	77.9	74.3	75.0	74.3	74.6
1992	67.7	69.7	73.5	75.0	78.6	75.0	75.9	75.0	75.4

(continued)

TABLE 11. (continued)

	in-area-only	with out-of-area industrial sources	with industrial and coal-fired power plant sources≠						
			1	2	2d	4	7	7a	7b
1993	68.6	70.6	74.3	75.8	79.3	75.8	76.8	75.8	76.3
1994	69.6	71.6	75.2	76.6	80.0	76.6	77.7	76.6	77.2
1995	70.5	72.5	76.0	77.4	80.7	77.4	78.7	77.4	78.0
1996	71.4	73.4	76.9	78.2	81.5	78.2	79.6	78.2	78.9
1997	72.4	74.4	77.8	79.0	82.2	79.0	80.6	79.0	79.8
1998	73.4	75.4	78.7	79.8	83.0	79.8	81.5	79.8	80.7
1999	74.5	76.5	79.6	80.7	83.7	80.7	82.5	80.7	81.6
2000	75.5	77.5	80.5	81.5	84.5	81.5	83.5	81.5	82.5

*Underlined values denote the year in which primary standards are violated.

≠All out-of-area data appears in Table 10.

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TABLE 12. PROJECTED OUTPUT IN EMITTING SECTORS
(millions of dollars)

SIC	1988	1989	1990	1991	1992	1993	1994	1995
20	430.51	451.79	474.12	497.56	522.15	547.96	575.05	603.47
28	89.62	93.74	98.05	102.56	107.28	112.21	117.37	122.77
32	297.44	308.48	319.92	331.79	344.10	356.87	370.11	383.84
33	90.87	94.93	99.17	103.60	108.23	113.07	118.12	123.40
34	332.03	343.05	354.44	366.21	378.37	390.93	403.91	417.32
35	289.01	300.45	312.35	324.72	337.58	350.95	364.85	379.30

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TABLE 13. EMPLOYMENT PER MILLION DOLLARS OF OUTPUT IN EMITTING SECTORS IN 1978

SIC	(a) Employment	(b) Output (millions of dollars)	(a)/(b) Employment per million dollars of output
20	169,450	41,730	4.06
28	108,820	39,540	2.75
32	69,620	17,160	4.06
33	1,205,600	37,130	32.47
34	1,652,600	39,190	42.17
35	2,337,000	61,300	38.12

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SECTION 5

ECONOMIC LOSSES TO THE COLUMBUS SMSA ATTRIBUTABLE TO OUT-OF-AREA CONTRIBUTIONS TO TSP

In this section we discuss the calculation of losses and report our results for each of the seven scenarios considered. The reader is reminded that we use a worst case approach in the sense that when violations occur, all new industrial activity from emitting sectors is prohibited. The amended provisions of the Clean Air Act provide for "offset" strategies which, if implemented in the Columbus SMSA, would ameliorate the changes reported here. Offset strategies, however, are not only subject to economic considerations, but also to political, historical, and other constraints. Under the offset provision, a complicated set of emission adjustments would have to be made. This might involve shutting down certain polluting facilities in order that more economically productive industries could use the resulting pollution increments. In any event, we have no way of dealing with the offset issue in this report. Our results, then, should be interpreted as representing upper bound estimates of losses if (1) primary TSP standards are fully enforced and (2) offset strategies are not used in the Columbus SMSA area.

Taking the long-range transport contribution into account, potential economic losses can be calculated by taking the difference in industrial gross product and employment originating by two-digit Standard Industrial Classification (SIC) code between the years in which violations are observed with and without the long-range contribution. Only the TSP emitting industries in Columbus are considered since they would be the only industries effected by pollution curtailment. Polluting industries were identified in Table 8, which showed actual emissions by two-digit SIC in the Columbus SMSA. These industries are food and kindred products (SIC 20), chemicals and allied products (SIC 28), stone, clay, and glass products (SIC 32), primary metals (SIC 33), fabricated metals (SIC 34), and machinery except electrical (SIC 35). The projections of gross product originating in all manufacturing sectors for the Columbus SMSA are found in Appendix B. Table B-1 contains the data for 1976 and 2000 while Table B-2 provides the annual values associated with the 1976-2000 growth rate. Table 12 is derived from the Appendix B tables and shows the anticipated dollar value of output from the emitting sectors beginning with 1988 used in our calculations. From the year of violation for any scenario, then, annual dollar losses are calculated as the difference between what discounted gross product originating would have been if historic growth patterns continued and the level fixed in the year of violation. Total cumulative discounted losses are the sum over the years from violation to 2000. Employment losses are calculated in the same manner. For employment losses, national data was used to estimate employment per million dollars of output. Employment multipliers for the emitting sectors are presented in Table 13. Our monetary values in the text and Appendix C

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are presented in 1988 dollars to permit comparisons between scenarios and cases.

In presenting our results, losses for each scenario are presented in terms of annual undiscounted losses, annual and total discounted losses, and employment losses. Only discounted gross product originating losses are relevant to the discussion of monetary losses. The assumed discount rate is 10%. Tables 14-16 contain the results for scenario 1, Tables 17-19 for scenarios 2, 4, 7a, and 7b, Tables 20-22 for scenario 2d, and Tables 23-25 for scenario 7. Scenarios 2, 4, 7a, and 7b are reported in the same tables as violation occurs in the same year for all four cases and, as a consequence, losses are identical. Undiscounted losses are reported to assist the reader in verifying our results. We discuss our results in terms of scenario comparison of absolute values and the percent losses are of manufacturing, emitting sector, and total anticipated gross regional product values.

Total cumulative discounted losses (1988 dollars), 1993-2000, for the business-as-usual scenario (2) from the six emitting sectors amount to $1,187.58 millions of dollars (Table 18). The value is the same for scenarios 4, 7a, and 7b. For all four scenarios, violation occurs in 1992. Total potential cumulative employment losses, 1993-2000, are 53,857 man-years (Table 19). Again, the employment losses are the same for scenarios 4, 7a, and 7b. Evidently the alternative assumptions underlying the four cases do not produce sufficiently different out-of-area contributions to Columbus SMSA TSP levels to cause differences in potential economic losses. The distribution of dollar losses in scenario 2 is uneven across manufacturing sectors with sector 20 experiencing 35.6% of total losses, sectors 32, 34, and 35 ranging from 16.4% to 17.8%, and sectors 28 and 33, respectively, 6.7% and 6.6%. Employment losses, however, show a different pattern with respect to individual sectors: sectors 34 and 35 together account for approximately 75.7% of total employment losses (evenly distributed in the two sectors), while sectors 33, 20, 32, and 28 account for, respectively, 11.7%, 7.9%, 3.8%, and 1%. The different distribution of losses across sectors as between dollar and employment measures is a reflection, of course, of the relative labor intensity of production in each aggregate sector. The method of calculating losses will produce the same percentage distribution of dollar and employment losses across sectors for all scenarios.

Scenario 1 (Table 11) results in violations in 1994. The reader will recall that this scenario differs from the base case scenario 2 only with respect to air quality standards; SO_2 and particulate standards are more stringent in scenario 1. Total cumulative discounted dollar loss from all emitting sectors, 1995-2000, is $682.87 million (Table 15) while total employment loss over the same period is 32,991 man-years (Table 16). These dollar losses are 57.5% of those experienced in scenario 2 while the corresponding percentage for employment losses is 61.3%. The more strict standards of scenario 1, then, provide a reasonably substantial reduction in potential economic losses to the Columbus SMSA. Of the seven scenarios examined, scenario 1 produces the smallest economic losses.

Violation occurs in 1987 under scenario 2d (Table 11) and results in the largest economic losses for the cases examined. It will be recalled that scenario 2d is identical to scenario 2 in all respects save one; scenario 2d

TABLE 14. SCENARIO 1: UNDISCOUNTED LOSSES (millions of dollars)

Sector	1995	1996	1997	1998	1999	2000
20	28.42	58.25	89.55	122.40	156.87	192.26
28	5.40	11.05	16.96	23.14	29.60	36.09
32	13.73	27.97	42.74	58.06	73.95	90.27
33	5.28	10.80	16.56	22.58	28.87	35.34
34	13.41	27.27	41.59	56.38	71.66	87.17
35	14.45	29.47	45.09	61.32	78.20	95.53
TOTAL	80.69	164.81	252.49	343.88	439.15	536.66

TABLE 15. SCENARIO 1: DISCOUNTED LOSSES
(1988 dollars)

Sector	1995	1996	1997	1998	1999	2000	Total 1995-2000
20	14.58	27.17	37.98	47.19	54.98	61.26	243.16
28	2.77	5.15	7.19	8.92	10.37	11.50	45.90
32	7.05	13.05	18.13	22.38	25.92	28.76	115.29
33	2.71	5.04	7.02	8.71	10.12	11.26	44.86
34	6.88	12.72	17.64	21.74	25.12	27.78	111.88
35	7.42	13.75	19.12	23.64	27.41	30.44	121.78
TOTAL	41.41	76.88	107.08	132.58	153.92	171.00	682.87

TABLE 16. SCENARIO 1: EMPLOYMENT LOSSES

Sector	1995	1996	1997	1998	1999	2000	Total
20	115	237	364	497	637	781	2,631
28	15	30	47	64	81	99	336
32	56	114	174	236	300	367	1,247
33	171	351	538	733	937	1,147	3,877
34	566	1,150	1,754	2,378	3,022	3,676	12,546
35	551	1,123	1,719	2,338	2,981	3,642	12,354
TOTAL	1,474	3,005	4,596	6,246	7,958	9,712	32,991

TABLE 17. SCENARIOS 2, 4, 7a, 7b: UNDISCOUNTED LOSSES

(millions of dollars)

Sector	1993	1994	1995	1996	1997	1998	1999	2000
20	25.81	52.90	81.32	111.15	142.45	175.30	209.77	245.16
28	4.93	10.09	15.49	21.14	27.05	33.23	39.69	46.18
32	12.77	26.01	39.74	53.98	68.75	84.07	99.96	116.28
33	4.84	9.89	15.17	20.69	26.45	32.47	38.76	45.23
34	12.56	25.54	38.95	52.81	67.13	81.92	97.20	112.71
35	13.37	27.27	41.72	56.74	72.36	88.59	105.47	122.80
TOTAL	74.28	151.70	232.39	316.51	404.19	495.58	590.85	688.36

TABLE 18. SCENARIOS 2, 4, 7a, 7b: DISCOUNTED LOSSES
(1988 Dollars)

Sector	1993	1994	1995	1996	1997	1998	1999	2000	Total 1993-2000
20	16.03	29.86	41.73	51.85	60.41	67.59	73.52	78.12	419.11
28	3.06	5.70	7.95	9.86	11.47	12.81	13.91	14.71	79.47
32	7.93	14.68	20.39	25.18	29.16	32.41	35.04	37.05	201.84
33	3.01	5.58	7.78	9.65	11.22	12.52	13.59	14.41	77.76
34	7.80	14.42	19.99	24.64	28.47	31.58	34.07	35.91	196.88
35	8.30	15.39	21.41	26.47	30.69	34.16	36.97	39.13	212.52
TOTAL	46.13	85.63	119.25	147.65	171.42	191.07	207.10	219.33	1,187.58

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TABLE 19. SCENARIOS 2, 4, 7a, 7b: EMPLOYMENT LOSSES

Sector	1993	1994	1995	1996	1997	1998	1999	2000	Total
20	105	215	330	451	578	712	852	995	4,238
28	14	28	43	58	74	91	109	127	544
32	52	106	161	219	279	341	406	472	2,036
33	157	321	493	672	859	1,054	1,259	1,469	6,284
34	530	1,077	1,643	2,227	2,831	3,455	4,099	4,753	20,615
35	510	1,040	1,590	2,163	2,758	3,377	4,021	4,681	20,140
TOTAL	1,368	2,787	4,260	5,790	7,379	9,039	10,746	12,497	53,857

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TABLE 20. SCENARIO 2d: UNDISCOUNTED LOSSES

(millions of dollars)

Sector	1988	1989	1990	1991	1992	1993	1994
20	20.28	41.56	63.89	87.33	111.92	137.73	164.82
28	3.94	8.06	12.37	16.88	21.60	26.53	31.69
32	10.64	21.68	33.12	44.99	57.30	70.07	83.31
33	3.89	7.95	12.19	16.62	21.25	26.09	31.14
34	10.67	21.69	33.08	44.85	57.01	69.57	82.55
35	11.01	22.45	34.35	46.72	59.58	72.95	86.85
TOTAL	60.43	123.39	189.00	257.39	328.66	402.94	480.36

(continued)

TABLE 20 (continued)

Sector	1995	1996	1997	1998	1999	2000
20	193.24	223.07	254.37	287.22	321.69	357.08
28	37.09	42.74	48.65	54.83	61.29	67.78
32	97.04	111.28	126.05	141.37	157.26	173.58
33	36.42	41.94	47.70	53.72	60.01	66.48
34	95.96	109.82	124.14	138.93	154.21	169.72
35	101.30	116.32	131.94	148.17	165,05	182.38
TOTAL	561.05	645.17	732.85	824.24	919.51	1,017.02

TABLE 21. SCENARIO 2d: DISCOUNTED LOSSES
(1988 Dollars)

Sector	1988	1989	1990	1991	1992	1993	1994
20	20.28	37.78	52.80	65.61	76.44	85.52	93.04
28	3.94	7.33	10.22	12.68	14.75	16.47	17.89
32	10.64	19.71	27.37	33.80	39.14	43.51	47.03
33	3.89	7.23	10.07	12.49	14.51	16.20	17.58
34	10.67	19.72	27.34	33.70	38.94	43.20	46.60
35	11.01	20.41	28.39	35.10	40.69	45.30	49.02
TOTAL	60.43	112.18	156.19	193.38	224.47	250.20	271.16

(continued)

TABLE 21 (continued)

Sector	1995	1996	1997	1998	1999	2000
20	99.16	104.06	107.88	110.74	112.75	113.78
28	19.03	19.94	20.63	21.14	21.48	21.60
32	49.80	51.91	53.46	54.50	55.12	55.31
33	18.69	19.57	20.23	20.71	21.03	21.18
34	49.24	51.23	52.65	53.56	54.05	54.08
35	51.98	54.26	55.96	57.13	57.85	58.11
TOTAL	287.90	300.97	310.81	317.78	322.28	324.06

TABLE 22. SCENARIO 2d: EMPLOYMENT LOSSES

Sector	1988	1989	1990	1991	1992
20	82	169	259	355	454
28	11	22	34	46	59
32	43	88	134	183	233
33	126	258	396	540	690
34	450	915	1,395	1,891	2,404
35	420	856	1,309	1,781	2,271
TOTAL	1,132	2,308	3,527	4,796	6,111

(continued)

TABLE 22 (continued)

Sector	1993	1994	1995	1996	1997
20	559	669	785	906	1,033
28	73	87	102	118	134
32	284	338	394	452	512
33	847	1,011	1,183	1,362	1,549
34	2,934	3,481	4,047	4,631	5,235
35	2,781	3,311	3,862	4,434	5,030
TOTAL	7,478	8,897	10,373	11,903	13,493

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TABLE 22 (continued)

Sector	1998	1999	2000	Total Man Years
20	1,166	1,306	1,450	9,193
28	151	169	186	1,192
32	574	638	705	4,578
33	1,744	1,949	2,159	13,814
34	5,859	6,503	7,157	46,902
35	5,648	6,292	6,952	44,947
TOTAL	15,142	16,857	18,609	120,626

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TABLE 23. SCENARIO 7: UNDISCOUNTED LOSSES
(millions of dollars)

Sector	1992	1993	1994	1995	1996
20	24.59	50.40	77.49	105.91	135.74
28	4.72	9.65	14.81	20.21	25.86
32	12.31	25.08	38.32	52.05	66.29
33	4.63	9.47	14.52	19.80	25.32
34	12.16	24.72	37.70	51.11	64.97
35	12.86	26.23	40.13	54.58	69.60
TOTAL	71.27	145.55	222.97	303.66	387.78

(continued)

TABLE 23 (continued)

Sector	1997	1998	1999	2000
20	167.04	199.89	234.36	269.75
28	31.77	37.95	44.41	50.90
32	81.06	96.38	112.27	128.59
33	31.08	37.10	43.39	49.86
34	79.29	94.08	109.36	124.87
35	85.22	101.45	118.33	135.66
TOTAL	475.46	566.85	662.12	759.63

TABLE 24. SCENARIO 7: DISCOUNTED LOSSES
(1988 Dollars)

Sector	1992	1993	1994	1995	1996
20	16.80	31.29	43.74	54.35	63.32
28	3.22	5.99	8.36	10.37	12.06
32	8.41	15.57	21.63	26.71	30.92
33	3.16	5.88	8.20	10.16	11.81
34	8.31	15.35	21.28	26.23	30.31
35	8.78	16.29	22.65	28.01	32.47
TOTAL	48.68	90.37	125.86	155.83	180.89

(continued)

TABLE 24 (continued)

Sector	1997	1998	1999	2000	Total 1992-2000
20	70.84	77.07	82.14	85.95	525.50
28	13.47	14.63	15.57	16.22	99.89
32	34.38	37.16	39.35	40.97	255.10
33	13.18	14.30	15.21	15.89	97.79
34	33.63	36.27	38.33	39.79	249.50
35	36.14	39.11	41.47	43.23	268.15
TOTAL	201.64	218.54	232.07	242.05	1,495.93

TABLE 25. SCENARIO 7: EMPLOYMENT LOSSES

Sector	1992	1993	1994	1995	1996
20	100	205	315	430	551
28	13	27	41	82	71
32	50	102	156	211	269
33	150	307	471	643	822
34	513	1,042	1,590	2,155	2,740
35	490	1,000	1,530	2,081	2,653
TOTAL	1,316	2,683	4,103	5,602	7,106

(continued)

TABLE 25 (continued)

Sector	1997	1998	1999	2000	Total
20	678	812	952	1,095	5,138
28	87	104	122	140	687
32	329	391	456	522	2,486
33	1,009	1,205	1,409	1,619	7,635
34	3,344	3,967	4,612	5,266	25,229
35	3,249	3,867	4,511	5,171	24,552
TOTAL	8,696	10,346	12,062	13,813	65,727

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assumes non-compliance with SIPs. In this scenario, the cumulative total discounted dollar loss for all sectors is $3,131.81 million (Table 21) while employment losses total 120,626 man-years (Table 22). The dollar losses are 264% of those experienced under scenario 2 while employment losses are 224%. Compared with the scenario yielding smallest losses (scenario 1), scenario 2d dollar and employment losses are, respectively, 459% and 366% of the corresponding scenario 1 values. The range of estimated losses from smallest to greatest, then, is quite large. This is understandable when one considers that projected violation of TSP primary standards in the Columbus SMSA occurs eight years earlier in scenario 2d than in scenario 1. This also emphasizes the critical role of SIP compliance to potential economic losses from long-range transport of airborne residuals.

The last scenario results reported are associated with high growth in electric demand and a 45-year plant life, scenario 7. Cumulative discounted dollar losses total $1,495.93 million (Table 24) while employment losses are 65,727 man-years (Table 25). These results correspond closely with those in the base case (scenario 2) as violation under scenario 7 occurs only one year earlier than under scenario 2. The similarity in results as between these two cases cannot be explicitly identified with different growth rates in the demand for electricity as plant life assumptions are also different as between the two cases (45-year life for scenario 7 and 35-year life for scenario 2). The alternative plant life assumptions are important: they determine the date of replacement of SIP plants and we know from other ORBES work that SIP plants account for a large percentage of regional emissions.[33] Nonetheless, the effect of the 45-year plant life assumption would be to maintain SIP units longer than under the scenario 2 plant life assumption and, as a consequence, the anticipated date of violation would tend to occur earlier. Despite this consideration, the higher growth rate in electric demand under scenario 7 and the longer plant life still suggest violation is only one year earlier than under scenario 2. Again, this reinforces the earlier conclusion with respect to scenarios 2d and 1 that losses to the Columbus SMSA from out-of-area sources are most sensitive to regional emission standards or compliance with standards and quite insensitive to additional capacity requirements.

The reader should bear in mind that the above conclusion suggests that emission standards or compliance with standards important to the calculated losses not in terms of TSP but rather SO_2. It is the emissions of SO_2 upwind of the Columbus SMSA that are converted to sulfate concentrations in the SMSA and lead to area TSP violations. In other economic damage work it was found that agricultural damages were largely insensitive to standards or compliance with standards and somewhat sensitive to alternative growth rates in electric demand.[34] In that case, the primary pollutant contributing to losses from utilities in NO_x (it contributes to O_3, the principal source of damages). Other than Illinois, there are no SIP standards for NO_x emissions and the NSPS and RNSPS standards are only minimal. In terms of economic damages from airborne residuals, comparison among several research efforts conducted for the ORBES project highlights the fact that economic damages from pollution are extremely complex and varied. While one pollutant, say small particulates, may be important to the economic losses from excess morbidity, another may be primarily responsible for monetarized agricultural

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damages and yet another to foregone subregional economic growth from long-range transport of SO_2 and conversion to SO_4. Policies (standards) which would ameliorate one type of economic damage may have a negligable or zero effect on other economic damages.

All results reported above were in terms of absolute numbers: millions of dollars or total man-year losses. It is difficult to assess the significance of such numbers unless they are put in perspective. Accordingly, we provide calculations in Tables 26-29 which portray losses as a percentage of Columbus SMSA gross regional product, gross manufacturing product, and gross product in emitting sectors. None of these calculations change any of the interpretive results discussed above. The only purpose is to provide some insight into the significance of the losses relative to larger aggregates.

Table 26 provides information on the percent losses are of Columbus SMSA gross regional product, 1988-2000, that is projected if no violations occur prior to 2000. The remaining columns show, by scenario, the percent annual losses are of annual gross regional product. The last row contains the percent total losses are of total gross regional product for each scenario. Total losses from scenario 2d are2.1% of cumulative gross regional product. As noted earlier, this represents the largest loss and, hence, the largest percent of cumulative gross regional product. Smallest loss occurred in the case of scenario 1 and the corresponding percent of cumulative gorss product is .46%. Scenarios 2, 4, 7a, and 7b each have loss values which are .8% of cumulative gross product while scenario 7 has 1.01%. In the context of overall economic activity in the Columbus SMSA, losses could be as high as 2.1% of cumulative gross regional product, 1988-2000, or as low as .46%.

Table 27 contains the same kind of information as found in Table 26 except losses are calculated as a percent of cumulative gross manufacturing product, 1988-2000. Cumulative losses as a percent of cumulative gross manufacturing product, 1988-2000, for respectively, scenarios 2d, 7, 2, 4, 7a, 7b, and 1 are 9.3%, 4.44%, 3.53%, 3.53%, 3.53%, 3.53% and 2.03%. Losses, then, range from a high of 9.3% of gross manufacturing product to a low of 2.03%. In terms of the manufacturing sector, then, potential losses from out-of-area contributions to TSP levels are quite large.

Table 28 provides similar calculations in terms of gross output originating from the emitting sectors. Percentages for scenarios 2d, 7, 2, 4, 7a, 7b, and 1, respectively, are 13.03%, 6.22%, 4.94%, 4.94%, 4.94%, 4.94%, and 2.84%. As one would expect, losses are quite significant with respect to gross product originating from emitting sectors.

Another view of the matter is to ask what percent losses are of gross output originating in emitting sectors in the last year, 2000. Those percentages range from a high of 14.69% to a low of 7.75%. Similar high and low percent values in terms of gross manufacturing product, respectively, are 11.9% and 6.28%. Relative to gross regional product, the high and low percentages are 2.67% and .46%. Viewed in this manner, the potential losses to the Columbus SMSA manufacturing sector from outside area contributions to ambient air appear very significant. In year 2000, the dollar value of output from the emitting sectors could be as much as 14.69% lower than would

TABLE 26. LOSSES AS A PERCENT OF SMSA GROSS REGIONAL PRODUCT 1988-2000, BY SCENARIO

Year	Discounted Gross Regional Product (millions of dollars)	Scenarios			
		2d	7	2,4,7a,7b	1
1988	10,675.94	0.57			
1989	10,813.59	1.04			
1990	10,947.93	1.43			
1991	11,079.00	1.75			
1992	11,206.76	2.00	0.43		
1993	11,331.26	2.21	0.80	0.41	
1994	11,452.54	2.37	1.10	0.75	
1995	11,570.60	2.49	1.35	1.03	0.36
1996	11,685.45	2.58	1.55	1.26	0.66
1997	11,797.13	2.63	1.71	1.45	0.91
1998	11,905.70	2.67	1.84	1.60	1.11
1999	12,011.16	2.68	1.93	1.72	1.28
2000	12,105.56	2.68	2.00	1.81	1.41
TOTAL	148,582.62	2.11	1.01	0.80	0.46

TABLE 27. LOSSES AS A PERCENT OF SMSA GROSS MANUFACTURING PRODUCT, 1988-2000, BY SCENARIO

Year	Discounted Gross Manufacturing Product (millions of dollars)	Scenarios			
		2d	7	2,4,7a,7b	1
1988	2,441.61	2.48			
1989	2,468.61	4.54			
1990	2,494.98	6.26			
1991	2,520.69	7.67			
1992	2,545.81	8.82	1.91		
1993	2,570.26	9.73	3.52	1.79	
1994	2,594.08	10.45	4.85	3.30	
1995	2,617.27	11.00	5.95	4.56	1.58
1996	2,639.82	11.40	6.85	5.59	2.91
1997	2,661.74	11.68	7.58	6.44	4.02
1998	2,683.04	11.84	8.15	7.12	4.94
1999	2,703.72	11.92	8.58	7.66	5.69
2000	2,723.79	11.90	8.89	8.05	6.28
TOTAL	33,665.45	9.30	4.44	3.53	2.03

TABLE 28. LOSSES AS A PERCENT OF SMSA GROSS PRODUCT IN EMITTING SECTORS, 1988-2000, BY SCENARIO

Year	Discounted Gross Product in Emitting Sectors (millions of dollars)	Scenarios			
		2d	7	2,4,7a,7b	1
1988	1,529.48	3.95			
1989	1,576.67	7.11			
1990	1,625.38	9.61			
1991	1,675.67	11.54			
1992	1,727.56	12.99	2.82		
1993	1,781.13	14.05	5.07	2.59	
1994	1,836.43	14.77	6.85	4.66	
1995	1,893.51	15.20	8.23	6.30	2.19
1996	1,952.45	15.41	9.26	7.56	3.94
1997	2,031.28	15.44	10.02	8.51	5.32
1998	2,076.09	15.31	10.53	9.20	6.39
1999	2,140.92	15.05	10.85	9.67	7.19
2000	2,206.26	14.69	10.97	9.94	7.75
TOTAL	24,034.83	13.03	6.22	4.94	2.84

otherwise be the case or as little as 7.75%. In terms of gross manufacturing product, dollar output could be as much as 9.3% lower or as little as 6.28%.

Finally, Table 29 provides the same type of percentage calculations for employment losses with respect to employment originating in emitting sectors, 1988-2000. Cumulative losses as a percent of cumulative emitting sector employment for scenarios 2d, 7, 2, 4, 7a, 7b, and 1, respectively, are 24%, 13%, 11%, 11%, 11%, 11%, and 6%. In year 2000, employment losses for scenarios 2d, 7, 2, 4, 7a, 7b, and 1, respectively, as a percent of projected employment are 38%, 28%, 26%, and 20%. In the emitting sectors, then, year 2000 employment could be as much as 38% lower or as little as 20% lower. These calculations, as well as those above for dollar losses, certainly suggest potential losses in the Columbus SMSA manufacturing sector are quite large.

TABLE 29. EMPLOYMENT LOSSES AS A PERCENT OF SMSA EMPLOYMENT IN EMITTING SECTORS

Year	Employment in Emitting Sectors	2d	%	7	%	2,4,71,7b	%	1	%
1988	31,172	1,132	3.6						
1989	32,345	2,308	7.1						
1990	33,569	3,527	10.5						
1991	34,834	4,796	13.8						
1992	36,150	6,111	16.9	1,316	3.6				
1993	37,517	7,464	19.9	2,682	7.1	1,368	3.6		
1994	38,937	8,896	22.8	4,103	10.5	2,786	7.2		
1995	40,410	10,372	25.7	5,574	13.8	4,258	10.5	1,473	3.6
1996	41,940	11,903	28.4	7,106	16.9	5,790	13.8	3,003	7.2
1997	43,530	13,493	30.1	8,696	20.0	7,379	17.0	4,595	10.6
1998	45,181	15,142	33.5	10,346	22.9	9,029	20.0	6,244	13.8
1999	46,889	16,857	36.0	12,062	25.7	10,744	22.9	7,958	17.0
2000	48,648	18,608	38.3	13,813	28.3	12,497	25.7	9,710	20.0
Total Man-Years	511,122	120,609	23.6 of Total	65,698	12.9 of Total	53,851	10.5 of Total	32,983	6.5 of Total

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NOTES

1. James J. Stukel, ed., Ohio River Basin Energy Study: Air Quality and Related Impacts (3 vols.), Ohio River Basin Energy Study Phase II, Grant No. EPA R805588, 1980.

2. Ibid.

3. The Columbus Standard Metropolitan Statistical Area (SMSA) is comprised of Delaware, Fairfield, Franklin, Madison, and Pickaway counties.

4. Figure 2 is adapted from a similar figure in Energy and Environment: An Intergovernmental Perspective, ed. Boyd Keenan, Institute of Government and Public Affairs, University of Illinois, January 1978.

5. Clean Air Act Amendments of 1977, U.S. Government Printing Office, Washington, D.C., 1977.

6. Gary L. Fowler et al., The Ohio River Basin Energy Facility Siting Model, Ohio River Basin Energy Study Phase II, Grant Nos. EPA R805588, R805589, and R805609 and Subcontract under Prime Contract EPA R805588, 1980.

7. As discussed later, part of the baseline pollution concentration is due to out-of-area sources.

8. Further details on ORBES scenarios may be found in Ohio River Basin Energy Study (ORBES): Main Report, by the ORBES Core Team, Ohio River Basin Energy Study Phase II, Grant Nos. EPA R804816, R805585, R805588, R805589, R805590, R805603, R805608, R805609, and Cooperative Agreement No. CR807395, 1980.

9. See unpublished Ph.D. dissertation by John M. Gowdy, The Potential Impact of Long-Range Air Pollution Transport on Economic Growth in Columbus, Ohio, for a discussion of alternative modeling techniques.

10. J. Kendrick and M. Jaycox, The Concept and Estimation of Gross State Product, Southern Economic Journal, vol. 32, no. 2, October 1965.

11. Ibid.

12. Albert Niemi, Gross State Product and Productivity in the Southeast (Chapel Hill: University of North Carolina Press, 1975), and W. L. L'Esperance, G. Nestel, and D. Fromm, Gross State Product and an Econometric Model of a State, Journal of the American Statistical Association (September 1969).

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13. One of the clearest descriptions of the Kendrick-Jaycox method is given by Niemi, Gross State Product, pp. 9-15.

14. Uyar Bulent, Industrial-Occupational Employment Projections: An Econometric Model of the Pittsburgh Standard Metropolitan Statistical Area, unpublished Ph.D. dissertation, University of Pittsburgh, 1977, p. 339.

15. Government employment data at the SMSA level is available in Employment and Earnings for States and Areas 1939-75, U.S. Bureau of Labor Statistics, 1977. U.S. Government Printing Office, Washington, D.C.

16. For example, the 1970 figures are found in Survey of Current Business, July 1971, Table 1.22.

17. Niemi, Gross State Product, pp. 10-11.

18. John M. Gowdy, Estimating Gross Manufacturing Product at the Subnational Level, Journal of Regional Science (forthcoming).

19. Wilford L. L'Esperance and Daniel E. Chall, The Concept and an Estimate of Gross Urban Product, working paper prepared for the Department of Development, City of Columbus, Ohio, June 1979, p. 17.

20. Albert Niemi, A Re-Examination of the Kendrick-Jaycox Method of Estimating Gross State Product, Review of Regional Studies, vol. 2., no. 3 (Spring 1972), p. 123.

21. National Income and Product Accounts of the United States 1929-74, U.S. Department of Commerce, Bureau of Economic Analysis, Washington, D.C., and Survey of Current Business, July 1977.

22. This procedure was suggested by M. Mills of Teknekron Research, Inc.

23. Stukel, Ohio River Basin Energy Study: Air Quality and Related Impacts.

24. See Walter P. Page and John M. Gowdy, The Regional Economic Impacts of Long-Range Air Pollution Transport Associated with PSD Requirements, Papers and Proceedings, Sixth National Conference on Energy and Environment, May 22, 1979, Pittsburgh, Pennsylvania.

25. Data provided by Teknekron Research, Inc. and reported in Stukel, Ohio River Basin Energy Study: Air Quality and Related Impacts.

26. Air Quality Data - 1976 Annual Statistics, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, N.C., March 1978.

27. Complete results of this work may be found in Stukel, Ohio River Basin Energy Study: Air Quality and Related Impacts.

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28. Walter P. Page, Doug Gilmore, and Geoffrey Hewings, An Energy and Fuel Demand Model for the Ohio River Basin Energy Study Region, Ohio River Basin Energy Study Phase II, Grant No. EPA R805585 and Subcontract under Prime Contract EPA R805588, 1980.

29. Fowler, The Ohio River Basin Energy Facility Siting Model.

30. Teknekron Research, Inc., Selected Impacts of Electric Utility Operations in the Ohio River Basin (1976-2000): An Application of the Utility Simulation Model. Vol. III of Stukel, Ohio River Basin Energy Study: Air Quality and Related Impacts.

31. Stukel, Ohio River Basin Energy Study: Air Quality and Related Impacts.

32. See Stukel, Ohio River Basin Energy Study: Air Quality and Related Impacts, for evidence concerning the time trend of projected emissions.

33. See emissions patterns reported in Teknekron, Selected Impacts of Electric Utility Operations.

34. See Walter Page et al., Estimating Regional Losses to Agricultural Producers from Airborne Residuals in the Ohio River Basin Energy Study Region, 1976-2000, Ohio River Basin Energy Study Phase II, Grant No. EPA R805585 and Subcontract under Prime Contract EPA R805588, 1980.

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APPENDIX A

CALCULATION OF GROSS AREA PRODUCT

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TABLE A-1. OHIO GROSS GOVERNMENT PRODUCT, 1960-1976

Year	(a) Compensation of Civilian Government Employees in the U.S.	(b) Wages and Salaries of Civilian Government Employees in the U.S.	(c) Ratio (a/b)	(d) Ohio Civilian Government Employees Wages and Salaries	(e) Ohio Gross Government Product
1960	42083	38735	1.086	1739	1888.6
1961	45569	41859	1.089	1892	2060.4
1962	49074	45052	1.089	1971	2146.4
1963	52991	48480	1.093	2062	2253.8
1964	57437	52472	1.095	2273	2488.9
1965	62152	56930	1.092	2441	2665.6
1966	69179	62909	1.100	2659	2924.9
1967	74760	69352	1.078	2920	3147.8
1968	85721	77528	1.106	3229	3571.3
1969	94025	84862	1.108	3533	3914.6
1970	106036	95290	1.113	3949	4395.2
1971	117658	105064	1.120	4319	4837.3
1972	129846	115626	1.123	4742	5325.3

(continued)

TABLE A-1 (continued)

Year	(a) Compensation of Civilian Government Employees in the U.S.	(b) Wages and Salaries of Civilian Government Employees in the U.S.	(c) Ratio (a/b)	(d) Ohio Civilian Government Employees Wages and Salaries	(e) Ohio Gross Government Product
1973	142882	126463	1.130	5256	5939.3
1974	157056	137486	1.142	5624	6422.6
1975	175468	152314	1.152	6154	7089.4
1976	190362	163632	1.163	6711	7804.9

TABLE A-2. GROSS FARM PRODUCT OF OHIO, 1960-1976

	1960	1961	1962	1963
Cash Receipts from Marketing	1005.0	1028.6	1055.4	1055.4
Value of Home Consumption	42.0	40.3	36.3	33.5
Gross Rental VAlue of Dwellings	122.5	123.7	128.1	117.1
Net Change in Inventories	14.0	-4.4	-23.3	7.8
Total Credits	1183.5	1188.2	1196.5	1213.8
Feed	155.2	158.9	170.2	183.8
Livestock	43.0	56.3	64.4	61.7
Seed	18.9	18.8	20.3	21.4
Fertilizer	62.8	53.3	61.0	66.5
Repairs & Operation of Equipment	152.3	147.9	150.0	144.0
Miscellaneous Operating Expenses	93.0	93.0	95.1	95.9
Net Rent to Non-Farm Landlords	22.8	24.6	21.2	24.1
Total Debits	546.7	552.8	582.2	597.4
Gross Farm Product	636.8	635.4	614.3	616.4

(continued)

TABLE A-2 (continued)

	1964	1965	1966	1967
Cash Receipts from Marketing	1107.7	1098.6	1279.9	1211.9
Value of Home Consumption	30.9	27.8	27.4	24.4
Gross Rental Value of Dwellings	112.3	114.9	115.5	119.4
Net Change in Inventories	-52.2	9.3	36.4	-22.1
Total Credits	1198.7	1250.6	1459.2	1332.9
Feed	175.7	168.1	182.0	181.5
Livestock	60.1	56.1	69.0	65.4
Seed	22.0	23.3	24.3	25.1
Fertilizer	71.1	70.1	77.0	82.8
Repairs & Operation of Equipment	136.1	141.7	145.9	154.5
Miscellaneous Operating Expenses	101.3	104.4	107.9	116.1
Net Rent to Non-Farm Landlords	27.6	34.6	44.6	27.0
Total Debits	593.6	598.2	650.7	652.4
Gross Farm Product	604.8	652.4	808.5	680.5

(continued)

TABLE A-2 (continued)

	1968	1969	1970	1971	1972	1973
Cash Receipts from Marketing	1262.6	1308.2	1323.5	1401.6	1577.6	2098.8
Non-Money Income		173.9	160.5	192.8	205.0	234.9
Value of Home Consumption	22.3					
Gross Rental Value of Dwellings	129.8					
Net Change in Inventories	3.5	-20.0	12.3	47.1	20.1	-44.5
Total Credits	1418.2	1462.1	1496.3	1641.5	1802.7	2289.2
Feed	163.0	175.1	179.6	172.9	174.6	252.2
Livestock	69.4	75.3	76.5	85.3	94.6	117.9
Seed	26.1	25.2	28.4	47.6	48.2	86.0
Fertilizer	76.6	72.1	74.9	104.4	100.9	111.2
Repairs & Operation of Equipment	158.8	164.1	178.5	172.3	173.5	200.8
Miscellaneous Operating Expenses	119.5	123.6	136.6	208.8	225.8	243.8
Net Rent to Non-Farm Landlords	35.0	32.4	34.6	39.8	72.1	92.0
Total Debits	648.4	667.8	709.1	831.1	889.7	1103.9
Gross Farm Product	769.8	794.3	787.2	810.4	913.0	1185.3

(continued)

TABLE A-2 (continued)

	1974	1975	1976
Cash Receipts from Marketing	2536.0	2584.6	2781.8
Non-Money Income	281.2	303.4	353.5
Net Change in Inventories	50.5	187.3	73.1
Total Credits	2867.7	3075.3	3208.4
Feed	297.8	280.4	300.6
Livestock	81.5	88.0	89.0
Seed	93.3	100.2	103.1
Fertilizer	238.4	269.2	257.5
Repairs & Operation of Equipment	239.2	261.4	294.9
Miscellaneous Operating Expenses	272.6	313.6	346.9
Net Rent to Non-Farm Landlords	184.5	151.9	155.2
Total Debits	1407.3	1464.7	1547.2
Gross Farm Product	1406.4	1610.6	1661.2

SOURCES: Farm Income Situation, USDA, Economic Research Service, Washington, D.C., August 1970, pp. 28 and 64 (data for 1960-68).

State Farm Income Statistics, USDA, Economic Research Service, Washington, D.C., 1978 (data for 1969-76).

TABLE A-3. NATIONAL RATIOS OF GROSS PRODUCT/VALUE ADDED IN MANUFACTURING

Year	Value Added	G.P.O.	Ratio
1960	164.0	143.9	.877
1961	164.3	143.8	.875
1962	179.1	157.5	.879
1963	192.1	166.3	.866
1964	206.1	178.6	.866
1965	226.9	196.3	.865
1966	250.9	215.9	.861
1967	261.0	221.3	.845
1968	285.1	241.8	.848
1969	304.4	254.6	.836
1970	300.2	250.3	.834
1971	314.1	261.5	.832
1972	354.0	288.8	.816
1973	405.6	321.8	.793
1974	452.5	334.6	.739
1975	442.5	350.1	.791
1976	511.5	402.8	.787

TABLE A-4. COLUMBUS SMSA PRIVATE NON-FARM FACTORS

	1962	1963	1964	1965	1966
Mining	.038	.038	.038	.037	.035
Construction	.116	.115	.114	.104	.102
Trade	.098	.102	.106	.107	.107
Finance, Insurance, Real Estate	.149	.149	.150	.152	.152
Transportation, Communication, Utilities	.098	.100	.103	.098	.100
Services	.119	.119	.119	.118	.119
Manufacturing	.069	.070	.070	.067	.066

(continued)

TABLE A-4 (continued)

	1967	1968	1969	1970	1971
Mining	.033	.032	.037	,029	.026
Construction	.103	.116	.107	.098	.113
Trade	.107	.108	.110	.112	.115
Finance, Insurance, Real Estate	.154	.154	.152	.164	.172
Transportation, Communication Utilities	.103	.099	.103	.105	.111
Services	.118	.121	.121	.121	.127
Manufacturing	.065	.066	.070	.070	.070

(continued)

TABLE A-4 (continued)

	1972	1973	1974	1975	1976
Mining	.025	.027	.027	.027	.027
Construction	.128	.133	.117	.108	.102
Trade	.116	.120	.124	.125	.126
Finance, Insurance, Real Estate	.178	.187	.182	.181	.180
Transportation, Communication, Utilities	.117	.121	.114	.124	.114
Services	.128	.128	.128	.126	.132
Manufacturing	.070	.068	.069	.068	.066

TABLE A-5. CALCULATIONS FOR ADJUSTING GROSS MANUFACTURING PRODUCT

	$(VA/LP)_s$	+	$(VA/LP)_n$	=	adjusted GMP
1960	13830.0/7479.8	+	163998.5/83672.5	=	.943
1961	13306.8/7212.6	+	164281.1/83677.4	=	.940
1962	14579.8/7694.4	+	179081.1/89819.2	=	.950
1963	15506.1/8125.4	+	192082.9/93283.3	=	.927
1964	16477.0/8579.1	+	206193.6/98685.3	=	.920
1965	18358.8/9437.3	+	226939.9/106643.2	=	.914
1966	20132.1/10367.1	+	250880.1/117157.4	=	.906
1967	20435.4/10523.6	+	261983.8/123480.6	=	.915
1968	22151.1/11455.7	+	285058.9/132568.4	=	.900
1969	24192.6/12419.4	+	304440.7/142645.1	=	.913
1970	23141.0/12489.1	+	300227.6/153078.5	=	.945
1971	23991.7/12512.9	+	314138.4/156202.8	=	.954
1972	27171.0/13810.0	+	353994.0/174205.5	=	.968
1973	31174.3/15509.5	+	404376.2/193324.5	=	.961
1974	35088.7/16575.8	+	452497.0/208312.0	=	.975
1975	32292.2/15967.9	+	442485.2/209519.0	=	.957
1976	37724.5/17855.4	+	511471.1/233388.7	=	.964

SOURCE: Various issues of the Annual Survey of Manufactures published by the U.S. Department of Commerce.

TABLE A-6. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1976

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.292	.395	.163	548	708.016	279.666	115.407	1103.99
Construction	1.109	.065	.028	2782	3086.142	200.573	86.611	3373.33
Trade	1.217	.073	.271	8633	10506.361	766.964	2847.224	14120.55
Finance, Insurance, Real Estate	2.756	.214	.286	2233	6153.155	1317.450	1761.797	9232.40
Transportation, Communication, Utilities	1.405	.211	.184	3755	5274.196	1112.855	971.298	7358.35
Services	1.091	.063	.059	7609	8301.419	522.989	489.784	9314.192
Manufacturing	1.337	.093	.064	20753	27746.761	2589.449	1775.793	32103.003
								30947.29*

*Adjusted gross manufacturing product.

ABLE A-7. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1975

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.349	.375	.160	492	663.642	248.651	106.042	1018.33
Construction	1.148	.070	.026	2569	2949.212	206.445	76.080	3232.34
Trade	1.202	.070	.282	7937	9540.274	668.021	2691.732	12900.03
Finance, Insurance, Real Estate	2.827	.229	.291	1915	5413.705	1239.738	1577.350	8230.79
Transportation, Communication, Utilities	1.365	.254	.164	3320	4532.381	1149.378	742.602	6424.36
Services	1.081	.066	.036	6881	7440.222	494.496	264.909	8199.63
Manufacturing	1.303	.101	.070	18296	23847.329	2419.329	1679.029	27945.69
								26744.03*

*Adjusted gross manufacturing product.

TABLE A-8. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1974

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	Ohio Data and Estimates (millions of dollars) (d) YR	(e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.401	.328	.161	409	573.009	187.947	92.254	853.21
Construction	1.121	.063	.024	2572	2883.971	181.690	69.512	3135.17
Trade	1.179	.073	.286	7346	8658.482	632.069	2479.182	11769.73
Finance, Insurance, Real Estate	2.794	.233	.290	1810	5057.140	1178.314	1466.571	7702.03
Transportation, Communication, Utilities	1.347	.256	.164	3210	4324.933	1105.956	709.201	6140.09
Services	1.087	.067	.035	6255	6799.114	455.541	235.351	7490.01
Manufacturing	1.241	.099	.071	19163	23748.702	2351.122	1686.158	27785.98
								27091.33*

*Adjusted gross manufacturing product.

TABLE A-9. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1973

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.160	.473	.168	307	356.120	168.445	59.828	584.39
Construction	1.088	.060	.024	2476	2693.888	161.633	64.653	2920.17
Trade	1.160	.072	.285	6685	7754.600	558.331	2210.060	10523.00
Finance, Insurance. Real Estate	2.683	.231	.299	1753	4703.299	1086.462	1406.286	7196.05
Transportation, Communication, Utilities	1.345	.241	.161	3057	4111.665	990.911	66.278	5168.85
Services	1.074	.063	.030	5839	6271.095	395.079	188.133	6854.31
Manufacturing	1.293	.093	.069	17882	23121.426	2150.293	1595.378	26867.10
								25819.28*

*Adjusted gross manufacturing product.

TABLE A-10. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1972

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.203	.437	.195	319	383.757	167.702	62.205	613.66
Construction	1.124	.054	.029	2211	2485.164	134.199	72.070	2691.43
Trade	1.193	.068	.296	6026	7189.018	488.853	2127.949	9805.82
Finance, Insurance, Real Estate	2.828	.221	.289	1589	4493.692	993.106	1298.677	6785.48
Transportation, Communication, Utilities	1.373	.239	.152	2765	3796.345	907.326	577.044	5280.72
Services	1.094	.076	.027	5232	5723.808	435.009	154.543	6313.36
Manufacturing	1.274	.099	.073	15677	19965.412	1935.887	1457.893	23409.19
								22660.10*

*Adjusted gross manufacturing product.

TABLE A-11. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1971

Economic Sector	National Coefficients (a) YO/Yr	(b) KC/YO	(c) IBT/YO	(c) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.067	.513	.214	231	267.817	137.390	57.313	462.52
Construction	1.107	.058	.028	2141	2379.087	137.465	66.362	2573.91
Trade	1.164	.071	.297	5720	6658.080	474.724	1977.450	9110.25
Finance, Insurance, Real Estate	2.761	.227	.305	1499	4138.739	939.494	1262.315	6340.55
Transportation, Communication, Utilities	1.372	.235	.152	2501	3431.372	806.372	521.569	4759.31
Services	1.061	.079	.028	4925	5225.425	412.809	146.312	5784.55
Manufacturing	1.253	.105	.083	14283	17900.384	1879.540	1485.968	21265.89
								20287.66*

*Adjusted gross manufacturing product.

TABLE A-12. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1970

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.132	.511	.188	246	278.472	142.299	52.353	473.12
Construction	1.086	.062	.031	2162	2347.932	145.572	72.786	2566.29
Trade	1.157	.070	.286	5452	6307.964	441.557	1804.078	8553.60
Finance, Insurance, Real Estate	2.700	.245	.296	1387	3744.900	917.501	1108.490	5770.89
Transportation, Communication, Utilities	1.353	.234	.145	2258	3055.074	714.887	442.986	4212.95
Services	1.098	.078	.027	4660	5116.680	399.101	138.150	5653.93
Manufacturing	1.237	.101	.087	13799	17069.363	1724.006	1485.035	20278.404
								19163.09*

*Adjusted gross manufacturing product.

TABLE A-13. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1969

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	Ohio Data and Estimates (millions of dollars) (d) YR	(e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.102	.516	.192	211	232.522	119.981	44.644	397.15
Construction	1.106	.059	.030	2261	2500.666	147.539	75.020	2723.23
Trade	1.157	.069	.280	5120	5923.840	408.745	1658.675	7991.26
Finance, Insurance, Real Estate	2.652	.240	.284	1285	3407.820	817.877	967.821	5193.52
Transportation, Communication, Utilities	1.407	.222	.143	2104	2960.328	657.193	423.327	4040.85
Services	1.073	.080	.026	4139	4441.147	355.292	115.470	4911.91
Manufacturing	1.275	.092	.082	13806	17608.954	1620.024	1443.934	20672.91
								19527.63*

*Adjusted gross manufacturing product.

TABLE A-14. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1968

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	Ic) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.227	.492	.179	184	225.768	111.078	40.412	377.26
Construction	1.105	.061	.030	1941	2144.805	130.833	64.344	2339.98
Trade	1.176	.068	.272	4679	5502.504	374.170	1496.681	7373.36
Finance, Insurance, Real Estate	2.706	.231	.277	1192	3225.552	745.103	893.478	4864.13
Transportation, Communication, Utilities	1.438	.220	.134	1929	2773.903	610.259	371.703	3755.87
Services	1.071	.079	.027	3799	4068.729	321.430	109.856	4500.02
Manufacturing	1.322	.089	.082	12668	16741.103	1493.275	1367.525	19601.90
								17641.71*

*Adjusted gross manufacturing product.

TABLE A-15. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1967

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.225	.520	.173	173	211.925	110.201	36.663	358.79
Construction	1.102	.060	.027	1661	1830.422	109.825	49.421	1989.67
Trade	1.162	.069	.252	4373	5081.426	350.618	1280.519	6712.56
Finance, Insurance, Real Estate	2.796	.234	.281	1081	3022.476	707.259	849.316	4579.05
Transportation, Communication, Utilities	1.438	.214	.134	1785	2566.830	549.302	343.955	3460.09
Services	1.096	.080	.027	3370	3693.520	295.482	99.725	4088.73
Manufacturing	1.311	.089	.080	11599	15204.029	1353.159	1216.322	17773.51
								16262.76*

*Adjusted gross manufacturing product.

TABLE A-16. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1966

Economic Sector	National Coefficients (a) YO/YR	(B) KC/YO	(c) IBT/YO	Ohio Data and Estimates (millions of dollars) (d) YR	(e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.315	.477	.164	159	209.085	99.734	34.290	343.11
Construction	1.099	.060	.029	1551	1704.549	102.273	49.432	1856.25
Trade	1.149	.069	.251	4051	4654.599	321.167	1168.304	6144.07
Finance, Insurance, Real Estate	2.816	.242	.276	968	2725.888	659.665	752.345	4137.90
Transportation, Communication, Utilities	1.490	.201	.126	1688	2515.120	505.539	316.905	3337.56
Services	1.072	.085	.032	3011	3227.790	274.362	103.289	3605.44
Manufacturing	1.353	.083	.080	11331	15330.843	1273.12	1225.077	17829.04
								16153.11*

*Adjusted gross manufacturing product.

TABLE A-17. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1965

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.313	.482	.155	154	202.202	97.461	31.341	331.00
Construction	1.088	.053	.028	1336	1453.568	77.039	40.700	1571.31
Trade	1.146	.068	.249	3771	4321.566	293.866	1076.070	5691.50
Finance, Insurance, Real Estate	2.801	.244	.275	913	2557.313	623.984	703.261	3884.56
Transportation, Communication, Utilities	1.486	.190	.129	1591	2364.226	449.203	304.985	3118.41
Services	1.111	.084	.034	2798	3108.578	261.121	105.692	3475.39
Manufacturing	1.377	.088	.093	10237	13686.869	1204.444	1271.879	16164.19
								14774.07*

*Adjusted gross manufacturing product.

TABLE A-18. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1964

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (zxd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.334	.506	.169	148	197.432	99.901	33.366	330.70
Construction	1.054	.057	.030	1140	1201.560	68.489	36.047	1306.10
Trade	1.075	.069	.238	3763	4045.225	279.121	962.764	5287.11
Finance, Insurance, Real Estate	2.813	.249	.273	862	2424.806	603.777	661.972	3690.56
Transportation, Communication, Utilities	1.492	.196	.131	1569	2340.948	458.826	306.664	3106.44
Services	1.117	.086	.036	2459	2746.703	236.216	98.881	3081.80
Manufacturing	1.374	.088	.097	9096	12497.904	1099.816	1212.297	14810.02
								13625.22*

*Adjusted gross manufacturing product.

TABLE A-19. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1963

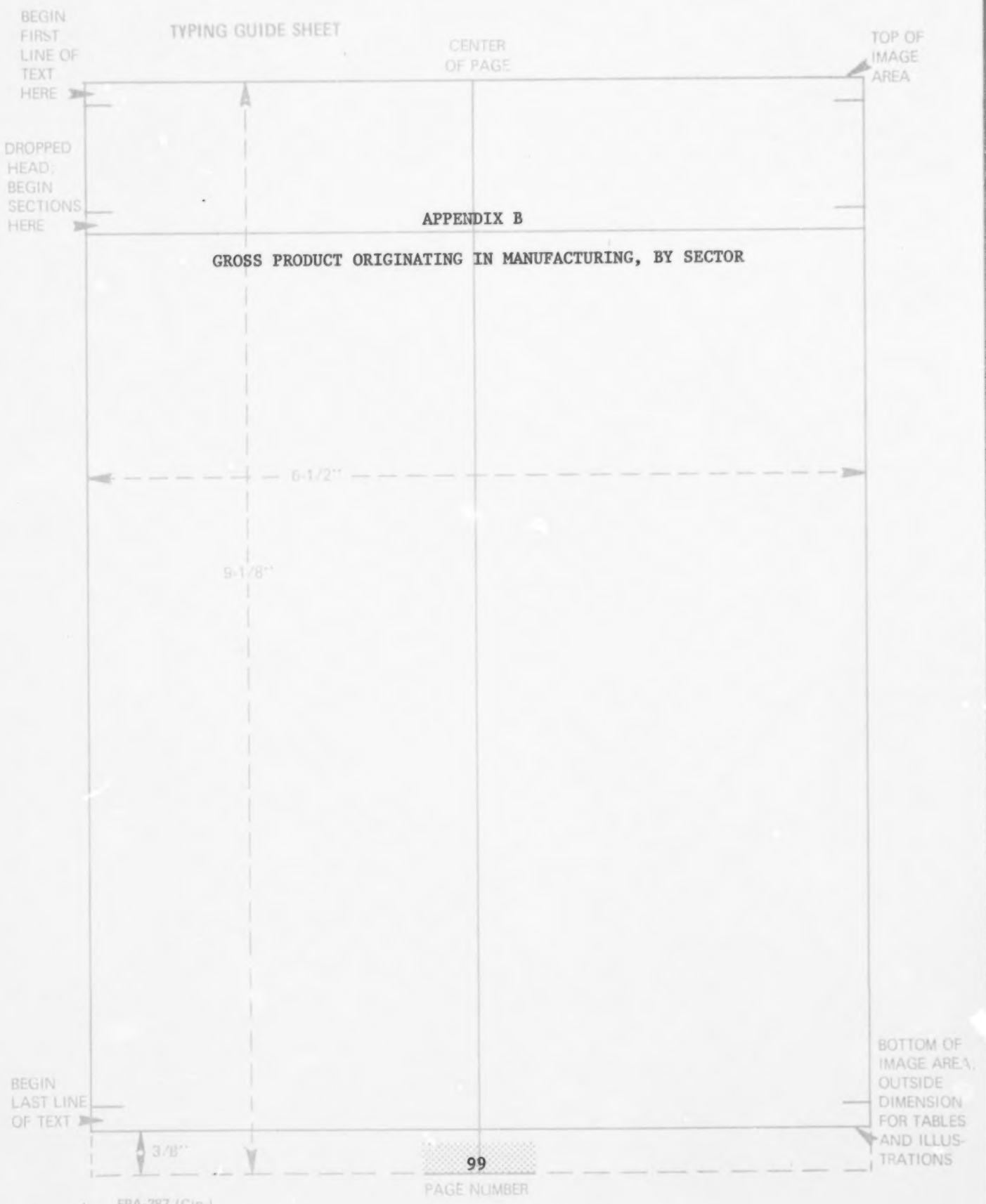
Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) KC (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.269	.554	.166	140	177.660	98.424	29.492	305.57
Construction	1.070	.061	.028	1063	1137.410	69.382	29.764	1236.55
Trade	1.116	.067	.227	3482	3885.912	260.356	882.102	5028.37
Finance, Insurance, Real Estate	2.561	.267	,298	813	2082.093	555.919	620.464	3258.47
Transportation, Communication, Utilities	1.434	.129	.067	1490	2136.660	275.629	143.156	2555.44
Services	1.209	.081	.034	2305	2786.745	225.726	94.749	3107.22
Manufacturing	1.354	.089	.099	8523	11540.142	1027.073	1142.474	13709.69
								12708.88*

*Adjusted gross manufacturing product.

TABLE A-20. WORKSHEET FOR ESTIMATING CURRENT DOLLAR GROSS PRODUCT ORIGINATING IN THE PRIVATE NON-FARM INDUSTRIES, OHIO, 1962

Economic Sector	National Coefficients (a) YO/YR	(b) KC/YO	(c) IBT/YO	(d) YR	Ohio Data and Estimates (millions of dollars) (e) YO (axd)	(f) (bxe)	(g) IBT (cxe)	(h) GPO (e+f+g)
Mining	1.296	.588	.165	135	174.960	102.876	28.868	306.70
Construction	1.065	.059	.030	1025	1091.625	64.406	32.749	1188.78
Trade	1.116	.066	.224	3410	3805.560	251.167	852.445	4909.17
Finance, Insurance, Real Estate	2.561	.266	.289	791	2025.751	538.850	585.442	3150.04
Transportation, Communication, Utilities	1.623	.123	.096	1444	2343.612	288.264	224.987	2856.86
Services	1.205	.079	.032	2167	2611.235	206.288	83.560	2901.08
Manufacturing	1.281	.093	.103	8157	10449.117	971.768	1076.259	12497.144
								11872.29*

*Adjusted gross manufacturing product.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GROSS PRODUCT ORIGINATING IN MANUFACTURING, BY SECTOR
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TABLE B-1. MANUFACTURING PRODUCT BY TWO-DIGIT SIC CODE

SIC Code	1976 Percent of Total Manufacturing	1976 GPO millions of dollars	2000 Percent of Total Manufacturing	2000 GPO Growth	Annual Compound Growth Rate
20	15.7	241.28	25.0	767.31	4.9
27	7.5	115.26	8.0	245.54	3.2
28	3.4	52.25	5.0	153.46	4.6
30	6.4	98.36	4.0	122.77	0.9
32	12.5	192.10	15.0	460.38	3.7
33	3.5	53.79	5.0	153.46	4.5
34	14.6	224.37	16.0	491.08	3.3
35	11.8	181.34	15.0	460.38	4.0
36	11.9	182.88	5.0	153.46	-0.7
37	6.8	104.50	1.0	30.69	-5.0
38	2.8	43.03	0.5	15.35	-4.2
Other	3.1	47.64	0.5	15.35	-4.6
TOTAL	100.0	1,536.80		3,069.23	2.9

TABLE B-2. GROSS PRODUCT ORIGINATING IN MANUFACTURING BY TWO-DIGIT SIC CODE

SIC Code	1977	1978	1979	1980	1981	1982	1983	1984
20	253.21	265.73	278.87	292.65	307.12	322.30	338.23	354.95
27	118.95	122.76	126.69	130.75	134.94	139.26	143.72	148.32
28	54.65	57.16	59.79	62.54	65.42	68.43	71.58	74.87
30	99.27	100.19	101.12	102.06	103.01	103.97	104.94	105.92
32	199.23	206.62	214.29	222.24	230.49	239.04	247.91	257.11
33	56.19	58.70	61.32	64.06	66.92	69.91	73.03	76.29
34	231.82	239.52	247.47	255.69	264.18	272.95	282.01	291.37
35	188.52	195.99	203.75	211.82	220.21	228.93	238.00	247.42
36	181.60	180.33	179.07	177.82	176.58	175.34	174.11	172.89
37	99.30	94.35	89.65	85.19	80.95	76.92	73.09	69.45
Other	99.09	106.83	113.87	120.17	125.71	130.50	134.48	137.63
TOTAL	1581.83	1628.18	1675.89	1724.99	1775.53	1827.55	1881.10	1936.22

(continued)

TABLE B-2 (continued)

SIC Code	1985	1986	1987	1988	1989	1990	1991	1992
20	372.50	390.91	410.23	430.51	451.79	474.12	497.56	522.15
27	153.07	157.97	163.03	168.25	173.64	179.20	184.94	190.87
28	78.31	81.91	85.68	89.62	93.74	98.05	102.56	107.28
30	106.91	107.90	108.90	109.91	110.93	111.96	113.00	114.05
32	266.65	276.54	286.80	297.44	308.48	319.92	331.79	344.10
33	79.70	83.26	86.98	90.87	94.93	99.17	103.60	108.23
34	301.04	311.03	321.36	332.03	343.05	354.44	366.21	378.37
35	257.22	267.41	278.00	289.01	300.45	312.35	324.72	337.58
36	171.68	170.48	169.29	168.10	166.92	165.75	164.59	163.44
37	65.99	62.70	59.58	56.61	53.79	51.11	48.56	46.14
Other	139.88	141.23	141.59	140.96	139.27	136.46	132.46	127.22
TOTAL	1992.95	2051.34	2111.44	2173.31	2236.99	2302.53	2369.99	2439.43

(continued)

TABLE B-2 (continued)

SIC Code	1993	1994	1995	1996	1997	1998	1999	2000
20	547.96	575.05	603.47	633.30	664.60	697.45	731.92	767.31
27	196.99	203.30	209.81	216.53	223.47	230.63	238.02	245.54
28	112.21	117.37	122.77	128.42	134.33	140.51	146.97	153.46
30	115.11	116.18	117.26	118.35	119.45	120.56	121.68	122.77
32	356.87	370.11	383.84	398.08	412.85	428.17	444.06	460.38
33	113.07	118.12	123.40	128.92	134.68	140.70	146.99	153.46
34	390.93	403.91	417.32	431.18	445.50	460.29	475.57	491.08
35	350.95	364.85	279.30	394.32	409.94	426.17	443.05	460.38
36	162.30	161.16	160.03	158.91	157.80	156.70	155.60	153.46
37	43.84	41.66	39.59	37.62	35.75	33.97	32.28	30.69
Other	120.68	112.77	103.42	92.52	80.01	65.81	49.82	30.70
TOTAL	2510.91	2584.48	1660.21	2738.15	2818.38	2900.96	2985.96	3069.23

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ECONOMIC LOSSES IN THE COLUMBUS SMSA
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TABLE C-1. PROJECTED TSP LEVELS IN THE COLUMBUS SMSA WITHOUT INDUSTRIAL OUT-OF-AREA SOURCES, 1976-2000* ($\mu g/m^3$)

	in-area-only	with coal fired power plant sources only						
		1	2	2d	4	7	7a	7b
1976	55.2	63.2	63.2	63.2				
1977	55.9	63.5	63.7	64.1				
1978	56.6	63.8	64.2	65.0				
1979	57.3	64.1	64.7	65.9				
1980	58.0	64.4	65.2	66.9				
1981	58.7	64.7	65.7	67.8				
1982	59.5	65.0	66.2	68.8				
1983	60.2	65.3	66.7	69.8				
1984	61.1	65.6	67.3	70.8				
1985	61.8	65.7	67.8	71.8				
1986	62.6	66.6	68.5	72.5	68.5	68.6	68.5	68.6
1987	63.4	67.4	69.3	73.1	69.3	69.5	69.3	69.4
1988	64.3	68.2	70.0	73.8	70.0	70.3	70.0	70.2
1989	65.1	69.0	70.7	74.5	70.7	71.2	70.7	71.0
1990	66.0	69.8	71.5	75.2	71.5	72.1	71.5	71.8
1991	66.8	70.6	72.3	75.9	72.3	73.0	72.3	72.6
1992	67.7	71.5	73.0	76.6	73.0	73.9	73.0	73.4
1993	68.6	72.3	73.8	77.3	73.8	74.8	73.8	74.3

(continued)

TABLE C-1 (continued)

	in-area-only	with coal fired power plant sources only						
		1	2	2d	4	7	7a	7b
1994	69.6	73.2	74.6	78.0	74.6	<u>75.7</u>	74.6	<u>75.2</u>
1995	70.5	74.0	<u>75.4</u>	78.7	<u>75.4</u>	76.7	<u>75.4</u>	76.0
1996	71.4	74.9	76.2	79.5	76.2	77.6	76.2	76.9
1997	72.4	<u>75.8</u>	77.0	80.2	77.0	78.6	77.0	77.8
1998	73.4	76.7	77.8	81.0	77.8	79.5	77.8	78.7
1999	74.5	77.6	78.7	81.7	78.7	80.5	78.7	79.6
2000	75.5	78.5	79.5	82.5	79.5	81.5	79.5	80.5

* Underlined values denote the year in which primary standards are violated.

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TABLE C-2. UNDISCOUNTED AND DISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS, SCENARIO 1
(millions of dollars)

UNDISCOUNTED LOSSES

Sector	1998	1999	2000	Total
20	32.85	67.32	102.71	202.88
28	6.18	12.64	19.13	37.95
32	15.32	31.21	47.53	94.06
33	6.02	12.31	18.78	37.11
34	14.79	30.07	45.58	90.44
35	16.23	33.11	50.44	99.78
Total	91.39	186.66	284.17	562.22

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DISCOUNTED LOSSES

Sector	1998	1999	2000	Total
20	12.67	23.60	32.73	69.00
28	2.38	4.43	12.09	18.90
32	5.91	10.94	29.97	46.82
33	2.32	4.31	11.82	18.45
34	5.70	10.54	28.82	45.06
35	6.26	11.60	31.79	49.65
Total	35.24	65.42	147.22	247.88

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TABLE C-3. UNDISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS, SCENARIO 2d

(millions of dollars)

	UNDISCOUNTED LOSSES				
Sector	1991	1992	1993	1994	1995
20	23.44	48.03	73.84	100.93	129.35
28	4.51	9.23	14.16	19.32	24.72
32	11.87	24.18	36.95	50.19	63.92
33	4.43	9.06	13.90	18.95	24.23
34	11.77	23.93	36.49	49.47	62.88
35	12.37	25.23	38.60	52.50	66.95
Total	68.39	139.66	213.94	291.36	372.05

Sector	1996	1997	1998	1999	2000	Total
20	159.18	190.48	223.33	257.80	293.19	1499.57
28	30.37	36.28	42.46	48.92	55.41	285.38
32	78.16	92.93	108.25	124.14	140.46	731.05
33	29.75	35.51	41.53	47.82	54.29	279.47
34	76.74	91.06	105.85	121.13	136.64	715.96
35	81.97	97.59	113.82	130.70	148.03	767.76
Total	456.17	543.85	635.24	730.51	828.02	4279.19

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TABLE C-4. DISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS, SCENARIO 2d
(millions of dollars)

	DISCOUNTED LOSSES				
Sector	1991	1992	1993	1994	1995
20	17.61	32.81	45.85	56.97	66.38
28	3.39	6.30	8.79	10.91	12.69
32	8.92	16.52	22.94	28.33	32.80
33	3.33	6.19	8.63	10.70	12.43
34	8.85	16.34	22.66	27.92	32.27
35	9.30	17.23	23.97	29.63	32.36
Total	51.40	95.39	132.84	164.46	190.93

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Sector	1996	1997	1998	1999	2000	Total
20	74.26	80.78	86.10	90.36	93.42	644.54
28	14.17	15.39	16.37	17.15	17.66	122.82
32	36.46	39.41	41.74	43.51	44.75	315.38
33	13.88	15.06	16.01	16.76	17.30	120.29
34	35.80	38.62	40.81	42.46	43.54	309.27
35	38.24	41.39	43.88	45.81	47.17	330.98
Total	212.81	230.65	244.91	256.05	263.84	1843.28

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TABLE C-5. UNDISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS, SCENARIOS 7 AND 7b
(millions of dollars)

Sector	UNDISCOUNTED LOSSES 1995	1996	1997	1998
20	28.42	58.25	89.55	122.40
28	5.40	11.05	16.96	23.14
32	13.73	27.97	42.74	58.06
33	5.28	10.80	16.56	22.58
34	13.41	27.27	41.59	56.38
35	14.45	29.47	45.09	61.32
Total	80.69	164.81	252.49	343.88

Sector	1999	2000	Total
20	156.87	192.26	647.75
28	29.60	36.09	122.24
32	73.95	90.27	306.72
33	28.87	35.34	119.43
34	71.66	87.17	297.48
35	78.20	95.53	324.06
Total	439.15	536.66	1817.68

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TABLE C-6. DISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS, SCENARIOS 7 AND 7b
(millions of dollars)

Sector	DISCOUNTED LOSSES 1995	1996	1997	1998
20	14.58	27.17	37.98	47.19
28	2.77	5.15	7.19	8.92
32	7.05	13.05	18.13	22.38
33	2.71	5.04	7.02	8.71
34	6.88	12.72	17.64	21.74
35	7.42	13.75	19.12	23.64
Total	41.41	76.88	107.08	132.58

Sector	1999	2000	Total
20	54.98	61.26	243.16
28	10.37	11.50	45.90
32	25.92	28.76	115.29
33	10.12	11.26	44.86
34	25.12	27.78	111.88
35	27.41	30.44	121.78
Total	153.92	171.00	682.87

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TABLE C-7. UNDISCOUNTED AND DISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS, SCENARIOS 7a, 2, AND 4 (millions of dollars)

UNDISCOUNTED LOSSES

Sector	1996	1997	1998	1999	2000	Total
20	29.83	61.13	93.98	128.45	163.84	477.23
28	5.65	11.56	17.74	24.20	30.69	89.84
32	14.24	29.01	44.33	60.22	76.54	224.34
33	5.52	11.28	17.30	23.59	30.06	87.75
34	13.86	28.18	42.97	58.25	73.76	217.02
35	15.02	30.64	46.87	63.75	81.08	237.36
Total	84.12	171.80	263.19	358.46	455.97	1333.54

DISCOUNTED LOSSES

Sector	1996	1997	1998	1999	2000	Total
20	13.92	25.93	36.23	45.02	52.20	173.30
28	2.64	4.90	6.84	8.48	9.78	32.64
32	6.64	12.30	17.09	21.11	24.39	81.53
33	2.58	4.78	6.67	8.27	9.58	31.88
34	6.34	11.95	16.57	20.42	23.50	78.78
35	7.01	12.99	18.07	22.34	25.83	86.24
Total	39.13	72.85	101.47	125.64	145.28	484.37

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TABLE C-8. DISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS AS A PERCENT OF GRP, BY SCENARIO

	Discounted GRP (millions of dollars)	Potential losses as a % of total GRP			
		2d	7, 7b	7a, 2, 4	1
1988	10675.94				
1989	10813.59				
1990	10947.93				
1991	11079.00	00.46			
1992	11206.76	00.85			
1993	11331.26	01.17			
1994	11452.54	01.44			
1995	11570.60	01.65	00.36		
1996	11685.45	01.82	00.66	00.33	
1997	11797.13	01.96	00.91	00.62	
1998	11905.70	02.06	01.11	00.85	00.30
1999	12011.16	02.13	01.28	01.05	00.54
2000	12105.56	02.18	01.41	01.20	01.22
Total	148,582.62	01.24	00.46	00.33	00.17

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TABLE C-9. DISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS AS A PERCENT OF GMP, BY SCENARIO

	Discounted GMP Manufactured Product (millions of dollars)	Potential losses as a % of gross manufactured product			
		2d	7, 7b	7a, 2, 4	1
1988	2441.61				
1989	2468.61				
1990	2494.98				
1991	2520.69	02.04			
1992	2545.81	03.75			
1993	2570.26	05.17			
1994	2594.08	06.34			
1995	2617.27	07.30	01.58		
1996	2639.82	08.06	02.91	01.48	
1997	2661.74	08.67	04.02	02.74	
1998	2683.04	09.13	04.94	03.78	01.31
1999	2703.72	09.47	05.69	04.65	02.42
2000	2723.79	09.69	06.28	05.33	05.40
Total	33,665.42	05.48	02.03	01.44	00.74

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TABLE C-10. DISCOUNTED LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS AS A PERCENT OF GROSS PRODUCT FROM EMITTING SECTORS, BY SCENARIO

	Discounted gross product in emitting sectors (millions of dollars)	Potential losses as a % of emitting sector output			
		2d	7, 7b	7a, 2, 4	1
1988	1529.48				
1989	1576.67				
1990	1625.38				
1991	1675.67	03.07			
1992	1727.56	05.52			
1993	1781.13	07.46			
1994	1836.43	08.96			
1995	1893.51	10.08	02.25		
1996	1952.45	10.90	03.94	02.00	
1997	2013.28	11.46	05.32	03.62	
1998	2076.09	11.80	06.39	04.89	01.70
1999	2140.92	11.96	07.19	05.87	03.06
2000	2206.26	11.96	07.75	06.58	06.67
Total	24,034.83	07.67	02.84	02.02	01.03

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TABLE C-11. POTENTIAL EMPLOYMENT LOSSES WITHOUT INDUSTRIAL OUT-OF-AREA CONTRIBUTIONS AS A PERCENT OF POTENTIAL EMPLOYMENT IN EMITTING SECTORS, BY SCENARIO

	Potential Emitting Sector Employment (man-years)	Losses (man-years)				%			
		2d	7, 7b	7a, 2, 4	1	2d	7, 7b	7a, 2, 4	1
1988	31,172								
1989	32,345								
1990	33,569								
1991	34,834	1267				03.64			
1992	36,150	2583				07.15			
1993	37,517	3950				10.53			
1994	38,937	5369				13.79			
1995	40,410	6844	1687			16.94	04.17		
1996	41,940	8374	3437	1531		19.97	08.20	03.65	
1997	43,530	9963	5257	3120		22.89	12.08	07.17	
1998	45,181	11615	7145	4772	1650	25.71	15.81	10.56	03.65
1999	46,889	13329	9104	6486	3365	28.43	19.42	13.83	07.18
2000	48,648	15080	11110	8237	5118	31.00	22.84	16.93	10.52
Total	511,122	78374	37740	24140	10133	15.33	07.38	04.72	01.98